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This handbook is designed to assist weapon system acquisition program managers and their staffs in balancing materiel readiness risks in programs with concurrency. It is divided into five major parts: the background of the requirement, program factors and their relationships, scheduling techniques and analysis, overview of risk analysis, and planning, management and acquisition strategies. Each of these parts is divided into chapters focusing on major elements of the subject. The handbook is compatible with existing DoD and Air Force regulations pertaining to systems acquisition and logistic support analysis. Pertinent sources for additional information are cited throughout the handbook, with a detailed bibliography included as an appendix.

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BALANCING MATERIEL READINESS RISKS AND CONCURRENCY IN WEAPON SYSTEM ACQUISITION: A HANDBOOK FOR PROGRAM MANAGERS

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PREFACE

Today, Program Managers (PM) face the problem of acquiring more complex systems, in less time, without sacrificing system effectiveness, readiness, and performance. Groups within the Air Force have recognized the need to provide topical guidance to PMs to assist them in meeting this responsibility. Balancing Materiel Readiness Risks and Concurrency in Weapon System Acquisition: A Handbook for Program Managers, was developed to offer advice to PMs and their staffs on some of the basic pitfalls to be dealt with in managing materiel readiness in the presence of concurrency.

This manual addresses the problem of balancing materiel readiness risks and concurrency by considering the four key issues (or problems) the PM must consider:

- the difficulty in managing for materiel readiness;
- the implementation of concurrency as a planning, management, or acquisition strategy;
- the integration of risk analysis in program planning and management; and
- the development of strategies for planning, managing, and acquiring a system in light of these factors.

This handbook was written with the assumption that the reader has only some familiarity with weapon system acquisition program management. For this reason, brief overviews of program management, scheduling techniques, and risk analysis have been provided. However, no attempt has been made to provide a detailed tutorial on these subjects. Where appropriate, more

detailed guides or sources of information on these subjects are referenced in the discussions. In addition, listings of significant information sources are also given.

The material for this handbook has come from a variety of sources which fall into three major categories:

- DoD guidebooks, handbooks, directives and instructions;
- studies and analyses of the acquisition process, program management, and specific weapon system acquisitions; and
- interviews with various program office and contractor personnel, as well as others with program/acquisition experience.

This handbook was prepared under the joint sponsorship of the Air Force Business Research Management Center (AFBRMC) and the Air Force Acquisition Logistics Center (AFALC/PTR), by Management Consulting & Research, Inc. (MCR) under Contract Number F33615-83-C-5050. It could not have been written without the guidance provided by AFBRMC and AFALC/PTR. MCR also received valuable assistance from numerous people in the various organizations contacted, including the F-16 System Program Office at Wright-Patterson AFB, the F-16 Program Office at General Dynamics/Fort Worth, and the Ballistic Missile Office. However, the contents and ideas in this handbook are not intended to reflect Air Force policy and are strictly those of the authors.

CONTENTS

SECTION		PAGE
PREFACE		i
Part I.	**BACKGROUND OF THE REQUIREMENT**	I-1
	Chapter 1. Introduction	1-1
	Chapter 2. Factors to Consider	2-1
Part II.	**PROGRAM FACTORS AND RELATIONSHIPS**	II-1
	Chapter 3. Overview of the System Acquisition Process	3-1
	Chapter 4. Factors Influencing Materiel Readiness	4-1
	Chapter 5. Concurrency-Related Activities	5-1
Part III.	**SCHEDULING TECHNIQUES AND ANALYSIS**	III-1
	Chapter 6. Summary of Scheduling Techniques	6-1
	Chapter 7. Structure of Concurrency Schedule Analysis	7-1
	Chapter 8. Analysis of Concurrency Schedule Risk	8-1
Part IV.	**OVERVIEW OF RISK ANALYSIS**	IV-1
	Chapter 9. Elements of Risk Analysis	9-1
	Chapter 10. Risk Analysis Alternatives	10-1
Part V.	**PLANNING, MANAGEMENT, AND ACQUISITION STRATEGIES**	V-1
	Chapter 11. Suggestions on Strategies	11-1

APPENDICES:

- APPENDIX A: REFERENCES
- APPENDIX B: GLOSSARY OF TERMS AND ABBREVIATIONS
- APPENDIX C: SUMMARY OF MAJOR ACQUISITION ACTIVITIES
- APPENDIX D: ADDITIONAL LOGISTIC SUPPORT ANALYSIS INFORMATION
- APPENDIX E: GUIDANCE ON DEVELOPING A SCHEDULING NETWORK

LISTS OF EXHIBITS

EXHIBIT		PAGE
1-1	Relationships Among Handbook Contents.	1-8
2-1	External Influences on Program Management Decisions.	2-2
3-1	Summary of Acquisition Technical Activities. . .	3-4
3-2	Summary Overview of the Acquisition Process. . .	3-6
3-3A	Interrelationships Between Systems Engineering and Configuration Management: Conceptual and Validation Phase	3-8
3-3B	Interrelationships Between Systems Engineering and Configuration Management: Full Scale Development and Production Phase	3-9
3-4	Inputs, Principal Activities, and Outputs of Concept Exploration Phase.	3-11
3-5	Activity Flow in Concept Exploration Phase . . .	3-13
3-6	Three-Level Work Breakdown Structure	3-14
3-7	Inputs, Principal Activities and Outputs of Demonstration and Validation Phase	3-17
3-8	Inputs, Principal Activities and Outputs of Full-Scale Development Phase	3-18
3-9	Inputs, Principal Activities and Outputs of Production and Deployment Phase.	3-21
3-10	Program Office Relationships	3-24
3-11	Typical Single Program PO.	3-25
3-12	Typical Multiple Program PO.	3-26
3-13	Ballistic Missile Office Organization.	3-27
3-14	F-16 SPO Organization Chart.	3-28
4-1	System Requirements and Characteristics Relationships.	4-4
4-2	Overview of Major Acquisition Technical Activities and Functions	4-6

LIST OF EXHIBITS (CONTINUED)

EXHIBIT		PAGE
4-3	Life Cycle Cost Expenditure Profile of A Typical Weapon System.	4-11
4-4	Progressive Definition of System Specifications.	4-13
4-5	Design Review and Baseline Development Relationship	4-17
4-6	Trends in Software and Hardware Costs.	4-23
4-7	Hardware-Software Development and Maintenance Cost Trends.	4-24
4-8	Types of Software.	4-26
4-9	Major Program Element Interrelationships and Dependencies	4-28
4-10	Example of Mission Profile Contents for an Air Launched Missile	4-29
4-11	System Life Profile.	4-31
4-12	Avionics Software Development Schedule	4-33
4-13	Life Cycle Impacts of Software Error Detection and Correction	4-35
4-14	Software Development, Verification and Validation Activities.	4-36
4-15	Test and Evaluation Cycle.	4-45
4-16	Integrated Logistic Support Task Flow During FSD.	4-56
4-17	Maintenance Task Flow and Integration with ILS .	4-57
4-18	Suggested Versus Actual Funding Profiles	4-67
5-1	Relationship of the T&E Program to the System Life Cycle	5-4
5-2	F-16 APG-66 Program Summary.	5-7
5-3	Concurrency in F-16 C/D Program Activities . . .	5-9
6-1	Examples of Gantt Charts	6-4

LIST OF EXHIBITS (CONTINUED)

EXHIBIT		PAGE
6-2	Example of Gantt Charting: Critical Path Template Timelines	6-6
6-3	Example of Gantt Charting: Reliability Program Elements	6-7
6-4	Example of Gantt Chart: F-16 Acquisition Logistics Master Schedule	6-12
6-5	Example of Gantt Chart: F-16 Air Vehicle Production Schedule	6-13
6-6	Example of Gantt Chart: F-16A/B Flight Test Plan	6-15
6-7	Development of PERT Network from Gantt Chart	6-20
6-8	Example of ARC and NODE Network	6-22
6-9	Example of Graphic Network Illustration	6-23
7-1	Three-Level Work Breakdown Structure	7-4
7-2	Concurrency Analysis Structure	7-6
7-3	Steps in Concurrency Analysis	7-10
8-1	Avionics Software Development Schedule	8-4
8-2	The Degree of Technological Uncertainty at Progressive Stages (RISK)	8-10
8-3	Relationship of Concurrency Options to Alternative Schedules	8-13
8-4	Cost Risk Considerations in System Design	8-16
8-5	Schedule Risk Considerations	8-17
8-6	Evaluation of Alternative Schedule	8-18
8-7	The Degree of Concurrency Realized as a Function of the Percent of the Baseline Time Saved	8-20
9-1	A Sample Structure for a Risk Assessment	9-8
9-2	A Sample Risk Assessment Flow Diagram	9-9
9-3	Components of Risk Analysis	9-15

PART I. BACKGROUND OF THE REQUIREMENT

Chapter 1. Introduction

Chapter 2. Factors to Consider

PART I. BACKGROUND OF THE REQUIREMENT

The purpose of this part of the handbook is to provide the reader with an understanding of why this handbook was developed, and what the key issues are to which the handbook responds. This background is given in two chapters. Chapter 1 introduces the handbook and provides a general discussion of the more recent emphasis on system or materiel readiness as an acquisition priority of the Program Manager. This chapter also includes a description of the purpose, scope, and organization of the handbook.

Chapter 2 addresses the major kinds of issues the Program Manager (PM) must address in dealing with the problem of balancing materiel readiness risks and concurrency in a program.

CHAPTER 1. INTRODUCTION

- Background/Purpose of the Handbook
- Scope of the Handbook
- Organization of the Handbook

CHAPTER 1. INTRODUCTION

BACKGROUND/PURPOSE OF THE HANDBOOK

Today, Program Managers (PM) face the problem of acquiring more complex systems, in less time, without sacrificing system effectiveness, readiness, and performance. Balancing Materiel Readiness Risks and Concurrency in Weapon System Acquisition: A Handbook for Program Managers results from a need to provide PMs with topical guidance on this problem. This problem, and the need to address it effectively, is reflected in several of the initiatives in the DoD Acquisition Improvement Program.[1/] These initiatives are:

- Initiative No. 9 - System Support and Readiness, establishing readiness objectives for each weapon development program and then designing in reliability and maintainability;
- Initiative No. 11 - Budgeting for Technological Risk, evaluating, quantifying and budgeting for technological risk;
- Initiative No. 12 - Test Hardware Funding, requiring that adequate test hardware be obtained to reduce overall schedule time and risks;
- Initiative No. 16 - Contractor Incentives for Reliability and Support, requiring that incentives be developed to encourage contractors to improve reliability and support;
- Initiative No. 21 - Standardization of Operational and Support Systems, requiring that development and use of standard operational and support systems achieve earlier deployment and better support of weapon systems in order to increase force readiness and support;

1/ Guidance on the Acquisition Improvement Program (AIP), Deputy Secretary of Defense Memorandum, 8 June 1983.

- Initiative No. 30 - Program Manager Control Over Logistics and Support Funds, requiring that logistics and support resources be shown in the Service POM by weapon system, and Program Managers be given more control of support resources; and

- Initiative No. 31 - Improved Reliability and Support involving improvement of reliability and support for shortened acquisition cycle programs.

In addition to the Acquisition Improvement Program (AIP), key DoD directives emphasize the need to design and plan for system readiness, shortening the acquisition cycle, and managing the risks in acquiring new systems.2/ Among the requirements included in these directives are the following:

- "Improved readiness and sustainability are primary objectives of the acquisition process. Resources to achieve readiness will receive the same emphasis as those required to achieve schedule or performance objectives." (DoDD 5000.1)

- "These resources [to achieve readiness] shall include those necessary to design desirable support characteristics into systems and equipment as well as those to plan, develop, acquire, and evaluate the support." (DoDD 5000.39)

Also, as directed in DoDD 5000.39 in the development of acquisition strategies, programs shall emphasize:

"(1) Early identification of reliability and maintainability (R&M) and supportability requirements.

(2) Evaluation of alternative support concepts and techniques to minimize cost and support risks.

(3) Test articles to support R&M and ILS development, test, and evaluation (DT&E).

2/ DoD Directive 5000.1, Major System Acquisitions, Under Secretary of Defense (Research and Engineering), 29 March 1982.

DoD Directive 5000.39, Acquisition and Management of Integrated Logistic Support for Systems and Equipment, Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), 17 November 1983.

(4) The early establishment of system readiness and supportability thresholds for verification or assessment during test and evaluation (T&E) before decision milestones."

DoDD 5000.39 also states that early ILS planning shall be based on "...documented logistic support analyses (LSA) to link design and ILS requirements to system readiness thresholds and to define detailed support element requirements."

At the same time there has been a significant increase in emphasis on designing and acquiring systems that can be "ready when needed." There has also been an increase in concern with the significant increases in the time it takes to acquire major weapon systems.3/ In 1977, the Defense Science Board examined the growth in the duration of the time required to acquire new weapon systems and found that:

> "...the front end period from initial program conception to DSARC II has increased substantially - from less than two years in the 1950's to an average of nearly five years at present.... [The Task Force] also concluded that the production and deployment period has increased considerably in recent years as a result of such pressures as operational test and evaluation, reduced concurrency and production stretchouts...."4/

Since that report was written, the use of concurrency as an acquisition strategy has once more become acceptable as a means of

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3/ While the emphasis in this handbook is on major weapon systems, (i.e., those requiring DSARC approval), many of these concerns also face and are equally applicable to less than major systems and programs.

4/ Report of the Acquisition Cycle Task Force - 1977 Summer Study, Defense Science Board, Office of the Under Secretary of Defense (Research and Engineering), 15 March 1978.

reducing acquisition time.[5/] However, as always, applying concurrency to a program creates problems in its own right, over and above those already facing the Program Manager. For example, there are risks associated with meeting readiness requirements goals in acquisitions where concurrency is being applied to reduce the time to field the system.

This handbook addresses the concerns facing Program Managers in balancing the weapon system's readiness requirements, and the risks associated with meeting these requirements goals, in acquisitions with concurrency. Its purpose is to raise questions and identify concerns of which the Program Manager should be aware and for which he should plan. Guidance is provided, in areas where no guidance previously existed, to assist the Program Manager in program planning.

SCOPE OF THE HANDBOOK

This handbook is designed to be used by Program Managers and their staffs in formulating decisions concerning the basic program acquisition strategy and management priorities. As such, it was developed with the fundamental assumption that the reader is familiar with the weapon system acquisition process and the basic

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5/ For a brief history of the ups and downs in the history of concurrency in various system acquisitions see: Gibson, Robert G., "Concurrency," Defense Systems Management Review - Defense Acquisition: The Process and the Problems, Defense Systems Management College, Autumn 1979; and Harvey, Thomas E., "Concurrency Today in Acquisition Management," Defense Systems Management Review - Defense Acquisition: Issues and Answers, Number 1, Volume 3, Defense Systems Management College, Winter 1980.

responsibilities of the various organizations involved in designing and acquiring Air Force systems (i.e., Air Force Systems Command, Air Force Logistics Command, Air Force Acquisition Logistics Center, etc.)

The reasons behind this assumption are threefold:

- It is not the intention of this handbook to be redundant and restate information already available in other standard sources, except in the context of supporting specific points of discussion.

- There are numerous sources already available which are designed to provide detailed discussions as well as basic understanding of specific elements of program management, system engineering, logistic support analysis, etc. These sources clearly state organizational and institutional positions with respect to the topics they address. They have been designed to relate factual information concerning roles, responsibilities, organizational relationships and procedures, and are essentially tutorial in nature. Lists of major sources are given by topic in Appendix A.

- This handbook is designed to raise issues and to be essentially cautionary in nature. It is not intended to provide a comprehensive discussion of the various topics addressed, since to attempt to do so would almost assuredly mean the inadvertant exclusion of a relevant example or approach. Rather, to the degree possible, it is a compendium of "things the Program Manager should think about."

Given these constraints, this handbook has been designed to focus on the four key issues (or problems) the Program Manager must consider in balancing materiel readiness risks and concurrency. These are:

- the definition of materiel readiness risks, the difficulty in managing materiel readiness, and the factors (i.e., activities, organizations and events) in the program which most directly relate to materiel readiness;

- the definition of concurrency, and the techniques for scheduling program activities, managing the imposition

of concurrency on a schedule, and analyzing the risks associated with applying concurrency;

- the integration of risk analysis in management, the conduct of risk analyses, and the various tools the PM can use to perform risk analysis; and

- the development of strategies for planning, managing and acquiring a system in light of these factors.

These topics are first addressed in terms of how they are problems the PM must manage. They are then each discussed in individual sections of the handbook. These sections contain brief discussions of basic information the PM and his staff should be aware of in considering these issues, and suggested techniques for addressing them.

ORGANIZATION OF THE HANDBOOK

This handbook is divided into five major parts, each of which is divided into chapters addressing specifically-related topics. A set of appendices follows the text. The appendices contain more detailed reference information supporting or elaborating on the chapter information.

The five parts of the handbook are designed to be self-contained discussions of different aspects of the Program Manager's problem. The reader can read all or only relevant parts of the handbook, depending on his or her interest, experience, and specific program responsibilities.

The five parts of the handbook are designed to address the major aspects of concern to the PM in managing the problem of balancing materiel readiness risks and concurrency in a system acquisition. These aspects can be thought of as the following:

- Defining the problem and determining the issues of which the PM needs to be aware. Part I of the handbook examines the background of the requirement to increase the emphasis on materiel readiness and major issues the PM must contend with in managing for readiness.

- Determining the nature of materiel readiness, in terms of a capability resulting from specific activities. Part II focuses on the structure of the acquisition process, discussing the activities and functions in a system acquisition with the greatest bearing on materiel readiness.

- Considering concurrency as a scheduling and management problem. Part III examines basic scheduling techniques the PM uses, the analysis of the impact of concurrency on the schedule and how the schedule risks associated with concurrency can be evaluated.

- Integrating risk analysis, assessment and management to assist in balancing materiel readiness and concurrency. Part IV examines the basic elements of conducting a risk analysis and how such analysis can be integrated to manage risks. Part IV also examines basic risk analysis tools and techniques.

- Developing an acquisition strategy to balance these elements in the context of the program's goals and constraints. Part V summarizes the problems and concepts discussed in the preceeding parts of the handbook and suggests strategies for addressing such problems.

Exhibit 1-1 shows the relationships among the major areas of concern and the remaining contents of the handbook. Part I, **BACKGROUND OF THE REQUIREMENT**, contains two chapters. Following this introductory chapter, Chapter 2 discusses the factors the Program Manager must consider in managing materiel readiness and its related risks, and concurrency.

Part II, **PROGRAM FACTORS AND RELATIONSHIPS**, addresses those elements in the program that relate to materiel readiness, emphasizing potentially concurrent relationships among those activities as well as with other program activities, functions and areas. It is composed of three chapters:

Part I. Background of the Requirement

Chapter 1. Introduction

Chapter 2. Factors to Consider

• Definition of Terms – Materiel Readiness – Concurrency • Managing for Readiness	Part II. Program Factors and Relationships Chapter 3. Overview of the Systems Acquisition Process Chapter 4. Factors Influencing Materiel Readiness Chapter 5. Concurrency-Related Factors Appendix C. Summary of Major Acquisition Activities Appendix D. Additional Logistic Support Analysis Information
• Concurrency as the Program Manager's Dilemma	Part III. Scheduling Techniques and Concurrency Analysis Chapter 6. Summary of Scheduling Techniques Chapter 7. Structure of Concurrency Scheduling Analysis Chapter 8. Analysis of Concurrency Schedule Risk Appendix E. Guidance on Developing a Schedule Network
• Integration of Risk Analysis and Management	Part IV. Overview of Risk Analysis Chapter 9. Elements of Risk Analysis Chapter 10. Risk Analysis Alternatives

Part V. Planning, Management, and Acquisition Strategies
Chapter 11. Suggestions for Strategies
Appendix A. References
Appendix B. Glossary of Terms and Abbreviations

Exhibit I-1. RELATIONSHIPS AMONG HANDBOOK CONTENTS

- Chapter 3 is a brief overview of the Air Force weapon system acquisition process, with a discussion of the relevant OSD and Air Force regulations, key organizations, and major program activities;

- Chapter 4 is a more detailed discussion of those elements in a weapon system acquisition program that directly relate to materiel readiness; and

- Chapter 5 examines the acquisition activities in light of potential concurrency relationships and discusses the activities particularly related to materiel readiness.

Part III, **SCHEDULING TECHNIQUES AND CONCURRENCY ANALYSIS**, contains three chapters:

- Chapter 6 provides a brief overview of major schedule analysis techniques generally used in program schedule planning and analysis;

- Chapter 7 describes a basic analytical approach for analyzing schedules in order to apply concurrency; and

- Chapter 8 describes the conduct and application of a concurrency schedule risk analysis.

Part IV, **OVERVIEW OF RISK ANALYSIS**, provides a general discussion of risk analysis. It has two chapters:

- Chapter 9 in which the elements of risk analysis are described; and

- Chapter 10 in which the various alternatives for performing risk analyses are discussed.

Part V, **MANAGEMENT AND ACQUISITION STRATEGIES**, is the final part of the handbook. In the final chapter (Chapter 11), various planning, management, and acquisition strategies are described.

In addition to these major discussions, there are five appendices. Appendix A contains a listing by topic of pertinent references of potential interest to Program Managers and their staffs. Appendix B is a Glossary of Terms and Abbreviations used

in this handbook. Appendix C includes a summary of major Air Force system acquisition activities. Appendix D has additional information on Logistic Support Analysis. Appendix E provides basic guidance on developing a schedule network.

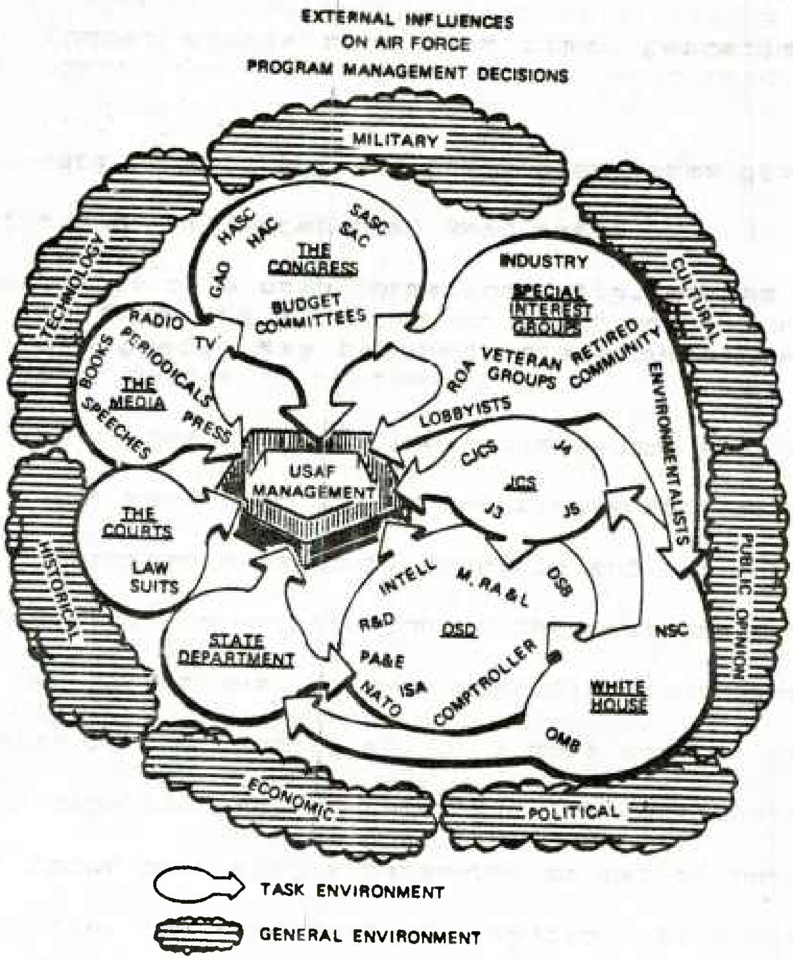
CHAPTER 2. FACTORS TO CONSIDER

- Definition of Terms
- Managing for Readiness
- Concurrency as the Program Manager's Dilemma
- Integration of Risk Analysis and Management

CHAPTER 2. FACTORS TO CONSIDER

The Progam Manager who must balance materiel readiness risks in system acquisitions with concurrency faces a variety of difficulties, not the least of which is confusion over what is meant by "materiel readiness" and "concurrency". In addition to these semantic difficulties, there are built-in difficulties associated with managing for a particular system capability, such as readiness. This is particularly true in an environment in which concurrency is being used as part of the acquisition strategy. Related issues, such as the priority of system support in the program, the use of planning and scheduling techniques, the integration of risk analysis and management and the management philosophy or strategy, all seriously influence the difficulty the Program Manager has in effectively balancing program concerns. This chapter is intended to briefly explore some of the major considerations the PM must face in balancing materiel readiness risks and concurrency. While these are not all of the issues the PM must contend with in managing for materiel readiness, they should be viewed as the starting point from which one should explore a program to consider other impacts.

In addition to the internal constraints, there is the outside world, as illustrated in Exhibit 2-1. All programs are vulnerable, to varying degrees, to impacts from political, social and economic conditions over which the Program Manager has no control. While these are real problems, techniques and suggestions for dealing with these areas are outside the scope of this



Source: Adapted from the Navy Program Manager's Guide, NAVMAT P-9494, Headquarters, Naval Material Command, July 1983

Exhibit 2-1. EXTERNAL INFLUENCES ON PROGRAM MANAGEMENT DECISIONS

handbook. The internal concerns, however, are of interest. The major issues concerning the Program Manager's ability to balance materiel readiness risks and the requirements of concurrency are briefly discussed below. These issues are:

- the definition of the terms "materiel readiness" and "concurrency",
- the problems associated with managing materiel readiness,
- the problems of managing concurrency, and
- the integration of risk analysis and program management.

DEFINITION OF TERMS

In examining the literature, policy directives and regulations, and in interviews with OSD, Air Force and contractor personnel, a basic source of confusion is revealed concerning the meaning of certain terms. Depending on the perspective, "materiel readiness" and "concurrency" may mean substantially different things to different people.

1. Materiel Readiness

While the term "readiness" is frequently used, it is rarely defined. Direction on Logistic Support Analysis (LSA) refers to readiness drivers.[1/] DoDD 5000.1 states that "system readiness is a primary objective of the acquisition process," but does not define what is meant. DoDD 5000.39 gives the following definition for System Readiness Objective:

1/ Logistic Support Analysis, MIL-STD-1388-1A, 11 April 1983.

"A criterion for assessing the ability of a system to undertake and sustain a specified set of missions at planned peacetime and wartime utilization rates. System readiness measures take explicit account of the effects of system design R&M, the characteristics and performance of the support system, and the quantity and location of support resources. Examples of system readiness measures are combat sortie rate over time, peacetime mission capable rate, operational availability, and asset ready rate."

The DoD Dictionary of Military and Associated Terms gives the following definition of Operational Readiness:2/

"The capability of a unit/formation, ship, weapon system or equipment to perform the missions or functions for which it is organized or designed. May be used in a general sense or to express a level or degree of readiness."

The problem of defining readiness has become even more significant since the recent policy emphasizing system readiness as being of equal importance as cost, schedule and performance (DoDD 5000.1 and 5000.39). Interpretation of the term tends to focus on either of two directions: a very specific measurement of capability which can be quantified, or a more general area covering a group of capabilities or elements. The first interpretation tends to focus on a single parameter or set of parameters which best typifies the readiness of a system. As noted in a discussion of this issue, this has tended to center on the calculation of Operational Availability:3/

2/ Department of Defense Dictionary of Military and Associated Terms, JCS Pub. 1, The Joint Chiefs of Staff, 1 June 1979.

3/ Brabson, Col. G. Dana, and Solomond, Dr. John P., "Readiness - Coequal", Concepts: Special Issue - The DoD Acquisition Improvement Program, Volume 5, Number 3, Defense Systems Management College, Summer 1982.

"There is a desire to focus on a single parameter if possible, because this would facilitate intercomparisons and simplify the overall process. As of this writing, there is a trend toward the use of operational availability (A_O) as that single parameter. In as much as operational availability is expressed as the ratio of uptime divided by total time, it is a measure both of the field reliability and the supportability of the hardware."

The interpretation of operational availability, as representative of a system's readiness, is desirable for certain types of analysis and planning, in that A_O does represent the collective productivity of the support system. However, it has its own associated difficulty due to differences in how availability is interpreted. Using this measure also tends to be too restrictive, for the purposes of achieving the goals of this handbook. Finally, it is not practical to try to manage a program to a single target quantity such as operational availability.

The second interpretation of system readiness is oriented toward a more general consideration of the system support structure, as indicated by the DoDD 5000.39 definition of System Readiness Objective. Readiness is viewed as the capability to not only operate the primary system, but also to have in place a full capability to maintain the system. This includes having the necessary support equipment, diagnostic equipment, adequately trained personnel, complete technical documentation, etc. Most of these capabilities are captured under the heading of logistic support. (See Appendix D for definitions of Integrated Logistics Support elements.)

In this handbook, the more general interpretation of materiel readiness, as represented by the logistic support system, has been

used. The major reason for this is that it allows for discussions of specific program activities and events which must be planned and monitored. Major areas of analysis such as manpower and personnel, training and training devices, and support equipment can be considered in terms of specific activities within the area, and how activities relate among different areas.

2. Concurrency

The term "concurrency" also presents a source of confusion for similar reasons. In the context of the weapon system acquisition process, concurrency has often been defined in a very restrictive sense as: "The conduct of the steps leading to production for inventory before the end of the full-scale development time span."[4/] In examining the literature and in interviews with SPO and contractor personnel, several other interpretations come to light, including:

- parallel (back-up) technological development;
- simultaneous, but independent, subsystem development and testing;
- co-production; and
- overlap of dependent, normally sequential activities.

Each of these interpretations is acceptable; however, not all are appropriate for consideration in this handbook. As in the case of the definition of materiel readiness, the least restrictive definition has been used in discussing concurrency: the overlapping of dependent, normally sequential activities.

4/ Report of the Acquisition Cycle Task Force: 1977 Summer Study, Defense Science Board, 15 March 1978.

Using this definition allows for the consideration of a greater variety of the problems facing Program Managers in managing concurrency. Activities in each of the Design and Development Phases can be considered, rather than only those in the Full Scale Development and Production Phases.

Another aspect in defining concurrency involves the recognition that there are different types of concurrency. A single program may use the concept of concurrently scheduling activities for a number of different reasons, in response to different requirements. One way of categorizing the different types of concurrency is:

- normal concurrency, used as a scheduling strategy for balancing workload and personnel assignments;
- planned concurrency, used as an acquisition strategy for allowing an early IOC or for reducing risk; and
- exceptional concurrency, used as a management strategy to compensate for unforeseen problems or to respond to a crisis.

Normal concurrency refers to the strategy of scheduling activities to maximize smooth workload distribution and minimize personnel assignment turbulence and peaks and valleys in accomplishing tasks. Most programs are planned to achieve smooth, continuous progress by a planned set of tasks designed to support specific progress milestones. These milestones frequently involve status reviews and go/no go decisions.

In a completely sequential schedule, involving no concurrency, activities in a phase initiated by these decision milestones should not be started until after the decision has been

finalized. In reality, such an approach would mean the cessation of work while a decision is being made and the reassignment of personnel to other productive tasks, if possible. This is a costly requirement which introduces unnecessary and undesirable confusion as well as resulting in inefficient use of resources (personnel and money). What is usually done on programs (as well as smaller projects) is to schedule continuous activities in the areas affected by these decisions. These tasks may be catch-up/ clean-up tasks, such as documentation; or they may involve preliminary planning and research for the following phase. In either case, concurrency is used as a schedule management technique.

Planned concurrency refers to the use of concurrency as a technique for reducing risk or achieving an earlier than normal initial operating capability (IOC). Concurrency has been used in the F-16 program, for example, as a risk management technique. Initial delivery dates for the F-16 C/D configurations have been set in order to allow for a longer test and evaluation period; and to allow for some latitude in schedule should problems arise. This has meant concurrently scheduling some of the system's integration tasks, but with the intention of protecting the ultimate Air Force delivery date. This type of concurrency is used in many different ways throughout programs to reduce risks of not meeting a key schedule milestone.

The other major application of planned concurrency is as a means of achieving an earlier IOC than would usually be achievable, using conventional program planning. Among large programs which have used this technique are the Air Force's F-16 and

Peacekeeper (MX) programs, and the Army's Multiple Launch Rocket System (MLRS). In these programs, the acquisition strategy has been designed to have overlapping activities or, in the case of the MLRS, the elimination of a whole design phase (the Demonstration and Validation Phase). Management safeguards have been built into the program planning in the form of more intensive status monitoring techniques, reporting systems and corrective action systems. While this concurrency is planned, it is not "normal" since it requires the use of additional planning and management strategies in order to not incur unacceptable risks to the programs.

Exceptional concurrency refers to circumstances under which concurrency is used as a crisis response. Normal and planned concurrency can be considered as crisis avoidance techniques. Exceptional concurrency is applied in situations where, for one reason or another, the original program plans must be changed part way through the program development. Changes in IOC, funding, system performance requirements or schedule slippage may force a Program Manager into concurrently scheduling, or eliminating, tasks which would normally not be scheduled or planned in such a way. Concurrency applied after the fact (i.e., after the initial program plans and schedules have been developed) can present unavoidable management problems. (These will be considered further later in this chapter.) It is important to recognize these differences in the types and reasons for applying concurrency, since:

- It is easy to not recognize when one has created a concurrent situation, with all of the potential advantages and disadvantages.
- It is important to recognize that not all concurrency is "bad".

Finally, concurrency must be considered in terms of its <u>magnitude</u>. This refers to the quantity, quality or site of the concurrency. Concurrency can be applied in different amounts, i.e., amount of time the activities overlap. Concurrency can also be applied at different levels (or sites) within the program, both within a given function or across functions.

The Program Manager should recognize, then, that in considering concurrency and its application in his or her program, it should be considerd in terms of:

- definition,
- type, and
- magnitude.

In addition to the problem of defining materiel readiness and concurrency, the PM must also develop a strategy for trying to optimize the system's ultimate readiness in light of other program goals.

MANAGING FOR READINESS

The system acquisition process has evolved over time, with priorities shifting from emphasizing system performance, to reducing acquisition costs (sometimes at the expense of total life cycle costs), to reducing acquisition time, to designing to

increased system, or materiel, readiness. In effect, what has happened has been that with each new priority, an additional requirement has been levied on the Program Manager to monitor and plan for another priority - somewhat similar to having to juggle four balls instead of the previous three.

The Program Manager is responsible for managing for system readiness, developing readiness objectives, controlling logistics and support resources, analyzing readiness drivers, monitoring the status of the design development decisions to assure that readiness is considered, and reporting on the supportability characteristics and requirements of the design.[5/]

The activities that influence a system's readiness are distributed among several program areas. In addition to Integrated Logistic Support/Logistic Support Analysis, activities that fall under the Systems Engineering area, particularly Specialty Engineering, also significantly influence readiness. Specialty Engineering collectively covers "those disciplines which support the design process by applying knowledge from a specific area to ensure system operability in its operational environment."[6/] Specialized engineering disciplines, such as reliability, maintainability, human and parts engineering, transportability, safety, and electromagnetic compatibility, may start out in the

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5/ See DoDD 5000.1, DoDD 5000.39 and MIL-STD-1388-1A for the policy relating to these responsibilities, and "Readiness - Coequal" by Brabson and Solomond (Concepts, Vol. 5, No. 3, Summer 1982) for a discussion and analysis of these responsibilities.

6/ System Engineering Management Guide, Defense Systems Management College, 3 October 1983.

early stages of the program being collectively directed under the single function, or program area, of Systems Engineering. As the program matures, many of these activities will be separated into individual program areas, such as ILS, while others will stay in the System Engineering program area.

Other program areas, such as Program Control and Business Management, play key roles in supporting the readiness management responsibilities of the Program Manager. These areas are responsible for monitoring and reporting on the status of the master schedule and the subschedules.

This distribution of responsibilities produces numerous management demands in order to give system readiness adequate exposure. Horror stories abound of decisions made during the acquisition process concerning the cancellation of apparently low priority items which were ultimately recognized as long leadtime, critical support equipment. Decisions were made because:

- the logistics impacts were not considered, or recognized; and
- logistics support has historically not been a high-priority item.

This latter point is evidenced by the historically frequent deferral of ILS/LSA requirements. Program office personnel involved in logistics have repeatedly expressed concern that because much of the substantive logistics analyses and decisions have been made later in the program, logistics-related funds have tended to be vulnerable to being used for other purposes. This results in development of elements of logistics support, such as

technical documentation and support equipment, being postponed until very late in the development process or possibly until after fielding of the system.

While increased emphasis on ILS should reduce some of the vulnerability of acquisition logistics resources, it will still be difficult to focus concentration on the diversified activities which relate to readiness. The ability to do this occurs on a program-by-program basis since efforts are still underway to develop institutional processes such those discussed in MIL-STD-1388-1A.

In addition to the problem of distributed activities relating to materiel readiness, there is another fundamental problem in managing materiel readiness risks, and that is relating materiel readiness to risk analysis. As discussed above, activities impacting the ability to produce a materielly "ready" system are distributed in many areas within the SPO and contractor. This in itself makes it difficult to coordinate these activities in a coherent plan for focusing on system readiness. Relating the status of these activities in a way that facilitates risk assessment becomes a real problem for the Program Manager.

Generally speaking, there are a number of different types of risk that may be considered in program management. The ones usually discussed are:

- cost risk,
- schedule risk,
- technical risk, and
- production risk.

There are numerous techniques available for evaluating each of these types of risk. (The major types of techniques to evaluate these risks are discussed in Part IV of this handbook.) Approaches have been developed for quantifying resource-related risks (cost and schedule), performance-related technical risks, and manufacturing/producibility risks. However, there is still much to be done in the area of developing techniques for quantifying readiness risks. Approaches for examining the collective nature of materiel readiness activities in light of the readiness goals of the program need to be developed so as to translate activity planning and status into quantifiable results. Until these types of tools are developed, the Program Manager must largely rely on the tools at his or her disposal that deal with the associated risks which can influence readiness (cost, schedule, technical and production). Once again, this is largely attributed to the distributed nature of readiness-related activities.

Even restricting concern to logistics-related activities does not resolve the issue. While this will reduce the number of areas of concern, it does not eliminate the problem of coming up with a coordinated assessment of the logistics-related risks. The most appropriate and reasonable approach the PM may be able to take is to apply conventional risk analysis techniques to the various readiness-related activities and develop a picture of the risks for the group. There is still much work to be accomplished in this area.

In addition to the problem of managing for materiel readiness, the PM faces another set of problems when applying concurrency in the program.

CONCURRENCY AS THE PROGRAM MANAGER'S DILEMMA

The use of concurrency as a planning, management or acquisition strategy presents inherent difficulties in program management. The very nature of concurrency implies a certain amount of complexity in that more than one activity is going on at a time. There are certain unavoidable difficulties associated with most applications of concurrency.

One potential risk in using concurrency is that of committing and expending resources on an ultimately unproductive activity. In concurrently scheduling sequentially dependent activities, the success of the dependent successor activity is frequently jeopardized. Usually this application of concurrency involves the initiation of efforts in an activity originally scheduled to start later, before completion of activities producing input to the originally later activity. In doing this, the manager makes certain assumptions concerning the results of the predecessor activity. Should those assumptions prove wrong, the efforts in the dependent activity may have to be revised, replaced with another approach, or possibly discarded. The resources spent on the effort are at risk, and additional resources may have to be expended in order to correct or compensate. This, in turn, can create a chain reaction of pressure on the schedule in other places, forcing the use of more concurrency.

Another difficulty is that communication and control of information becomes more difficult. In cases where normally sequential activities have been scheduled to overlap, information on the changing status of these activities becomes vital. Decisions in the predecessor activity can have significant (and sometimes detrimental) impacts on the dependent activity. Conversely, decisions made in the latter activity can ripple backwards, influencing the final outcome of the predecessor activity. Managers are faced with the need to have sufficiently responsive information control and status monitoring systems to support the more intensive management requirements that come with using concurrency.

Still another difficulty associated with using concurrency is the substantial increase in risk to the program that can occur. Generally, concurrency requires distributing resources in a way different from that of a sequentially dependent schedule. The manager may have more than one fully manned task occurring at the same time, if co-development is planned. In this case, the personnel resources assigned to the task will be at a much higher level than would generally be required if the tasks were not concurrent. The probability of success of each approach will indicate how much of these resources are at risk of not being successful.

Risks can also be incurred in the more conventional situation of sequentially dependent activities occurring at the same time. Depending on the manloading of these tasks, the same personnel could have originally been planned to work on both tasks, one after the other. Concurrency may require them to work

on both tasks at the same time, but with a lower level of production on each. In order to maintain a schedule, this may force the taking of shortcuts (e.g., deferring or eliminating documentation), increasing risks that the documentation or deferred analysis may not be available when needed; or that the concurrently performed activities will not be effectively or efficiently performed.

It is important for the manager to:

- understand the potential risks to the program of applying concurrency; and
- be able to make judicious decisions concerning how, when and where it is appropriate to use concurrency.

He must be able to make trade-offs between the benefits and risks of using a selected alternative. In addition to the problem of managing the concurrency and being able to make effective trade-offs, the PM must also be able to apply the results of risk analyses to resolving management problems.

INTEGRATION OF RISK ANALYSIS AND MANAGEMENT

Program Managers are required to perform risk analyses in order to identify and monitor elements of their programs which may threaten their planned completion. Generally this involves evaluating the current and projected status of key indicators and parameters. Many techniques have been developed to assist in this. Exhaustive work has been performed in the area of cost, schedule, technical and production risk assessment. The program office, or more frequently the contractor, reports on the results

of the various risk analyses conducted in conformance with direction.

The concern of the Program Manager is the integration of the results of these analyses in the actual management of the activities. This raises the whole question of the intention and purpose of risk analysis. Risk analysis is fundamentally aimed at identifying those elements of the program that could jeopardize the ultimate success of the program. Rather than assume that everything will go right or as planned (the Cockeyed Optimist approach) or that the worst case should be planned for (the Murphy's Law Will Prevail approach), risk analysis is intended to identify and assess the magnitude of real and potential dangers. Ideally, if the risks are accurately identified and effectively managed, then the failure should not occur. Conversely, one can always in retrospect tell exactly where the real risks were hiding when the worst comes true. Risk analysis and management is, then, a form of crisis avoidance.

A big question facing the Program Manager is how best to use the results of risk analysis. Research has shown that risk management is frequently on a separate path from risk analysis. The risk analysis in many cases may be primarily used to "answer the mail." Risk management may be an <u>implicit</u> rather than <u>explicit</u> activity. This is important to recognize. Just because something is not called risk management, it doesn't mean that the risks are not being managed! However, there should be a clear link between the results of the risk analysis and the management of the risks that have been identified through the analysis.

Interviews with experienced Government and contractor personnel show that frequently risk analysis is conducted by a separate group (the operations research group in the corner). Varying forms of discipline may be applied in conducting the risk analysis. Although these techniques may be rigorously evaluated initially, once approved they are often of little concern to any but the analysts. Reports are generated as required, the contents may or may not be surprising to the managers receiving them. In well run, effectively managed and structured programs, the reports on the assessment of the high, medium and low-risk elements may not come as a surprise, since they have usually been identified by the participants. Risk analysis can assist them in identifying alternatives and considering the magnitude of the potential problems. The analysis quantifies, in many cases, the qualitative evaluation of the participants as to areas of concern, magnitude of the potential hazard, viability of alternative courses of action, and probability of success.

Frequently, risks are managed implicitly throught the establishment of the management control systems. Programs in the Ballistic Missle Office, as an example, are organized to have regularly scheduled program element progress reviews. The status of the cost, schedule, and technical efforts are rigorously evaluated and action plans for managing concerns (risks) are developed and monitored. This is implicit or imbedded risk management in that the process fosters managing problems effectively, however, it is not explicitly called "risk management".

Another implicit approach to risk management advocated in most of the acquisition and design management guides is the rigorous and thorough review and validation of system requirements, starting with program initiation. In this way, the risk of designing a system which has unnecessary, inappropriate or unrealistic technical requirements can be reduced.

In managing risks, particularly materiel readiness risks, it becomes a particular concern of the managers, especially the Program Manager, to be able to integrate the risk assessments with management initiatives.

PART II. PROGRAM FACTORS AND RELATIONSHIPS

Chapter 3. Overview of the System Acquisition Process

Chapter 4. Factors Influencing Materiel Readiness

Chapter 5. Concurrency-Related Factors

PART II. PROGRAM FACTORS AND RELATIONSHIPS

This section focuses on the program activities and elements that relate to materiel readiness. A brief overview of major activities that occur in most Air Force acquisitions and the typical organizations in the Program Office (PO) is in Chapter 3. In Chapter 4 the program activities that more directly influence materiel readiness are discussed in greater detail. Chapter 5 considers how some of these activities may be influenced by the application of concurrency.

Appendix C provides additional details on the key acquisition activities, as outlined in A Guide for Program Management, AFSC Pamphlet 800-3, now in revision. Appendix D includes additional information on Integrated Logistics Support/Logistics Support Analysis.

CHAPTER 3. OVERVIEW OF THE SYSTEM ACQUISITION PROCESS

- Major Air Force Acquisition Activities
- Typical Acquisition Program Office Organization

CHAPTER 3. OVERVIEW OF THE SYSTEM ACQUISITION PROCESS

Systems acquired by the DoD are designed and developed according to a structured process of phased activities and decision milestones.[1/] The phases are designed to allow for a deliberate and careful determination of the requirements for a new system, minimizing the risks of committing resources to an unnecessary, unproductive, or impractical venture. The decision milestones are intended to determine, at key periods in the development process, if the system design is progressing adequately to make it reasonable to continue the investment, or if the need and the design/development approach are still appropriate.

The process for acquiring systems within the DoD is institutionalized through a series of regulations. The initial policy is set by OSD. The regulations, in the form of directives and instructions, apply to all of the Services. The Services, in turn, issue their own complementary regulations elaborating on the OSD policies, tailoring the specific application of the policies to the individual characteristics of the Service. Each major command, in turn, issues its own implementing regulations, or, as in the case of the major acquisition guidance from AFSC, in pamphlets.

The major policy directives and instructions issued by OSD that relate to the acquisition process are in the 5000 series.

1/ The term "system," as used in this guide, refers to not only the primary mission hardware and software, but also the support equipment, technical data, personnel, etc.

While there are numerous directives and instructions that are specifically germane to managing systems acquistions, the keystone policies are set down in two documents:

- DoD Directive 5000.1, Major System Acquisitions, and
- DoD Instruction 5000.2, Major System Acquisition Procedures.

These regulations are reviewed and revised as policy is changed, as are the Service implementing regulations, instructions, and pamphlets.[2/] Included in these policies are descriptions of the roles and responsibilities of organizations involved in systems acquisition, and the analyses which must be performed in each stage of the system's development.

In the following discussion the activities in the various phases of the systems acquisition process will be only briefly discussed. For more in-depth descriptions there are numerous guides published by the Defense Systems Management College (DSMC) and various groups within the Air Force and the other Services. Many of these are referenced in Appendix A. In this chapter, five major sources have been used:

2/ The most recent versions of these regulations were issued on 29 March 1982 (DoDD 5000.1) and 8 March 1983 (DoDI 5000.2). Many of the handbooks, guidebooks and Service regulations referenced in this handbook do not reflect these most recent revisions, particularly relating to milestone decision authorities. Where possible, differences between the former process as represented in these references, and the current process have been noted or corrected. However, the reader should be aware that in all cases that has not been possible and should review the current versions of the pertinent OSD and Air Force regulations for specific discussions on current responsibilities. Many of the relevant Air Force regulations are being revised but are substantially adequate for the purposes of this handbook. Listings of pertinent DoD regulations, organized by topic, are contained in Appendix A.

- Huffman, Major James W., Lozito, Major Vincent J., Jr. and Snyder, Major Larry A., Weapon Systems Acquisition Guide, Air Command and Staff College, Air University, Maxwell AFB, Alabama, May 1980.

- Runkle, Captain Marty T. and Smith, Captain Michael L., Systems Acquisition Guide, Air Command and Staff College, Air University, Maxwell AFB, Alabama, May 1978.

- Systems Engineering Management Guide, Defense Systems Management College, Ft. Belvoir, Virginia, 3 October 1983.

- Navy Program Manager's Guide, NAVMAT P-9494, Naval Material Command, July 1983.

- A Guide for Program Management, AFSCP 800-3, Air Force Systems Command, 9 April 1976 (in revision).

MAJOR AIR FORCE ACQUISITION ACTIVITIES

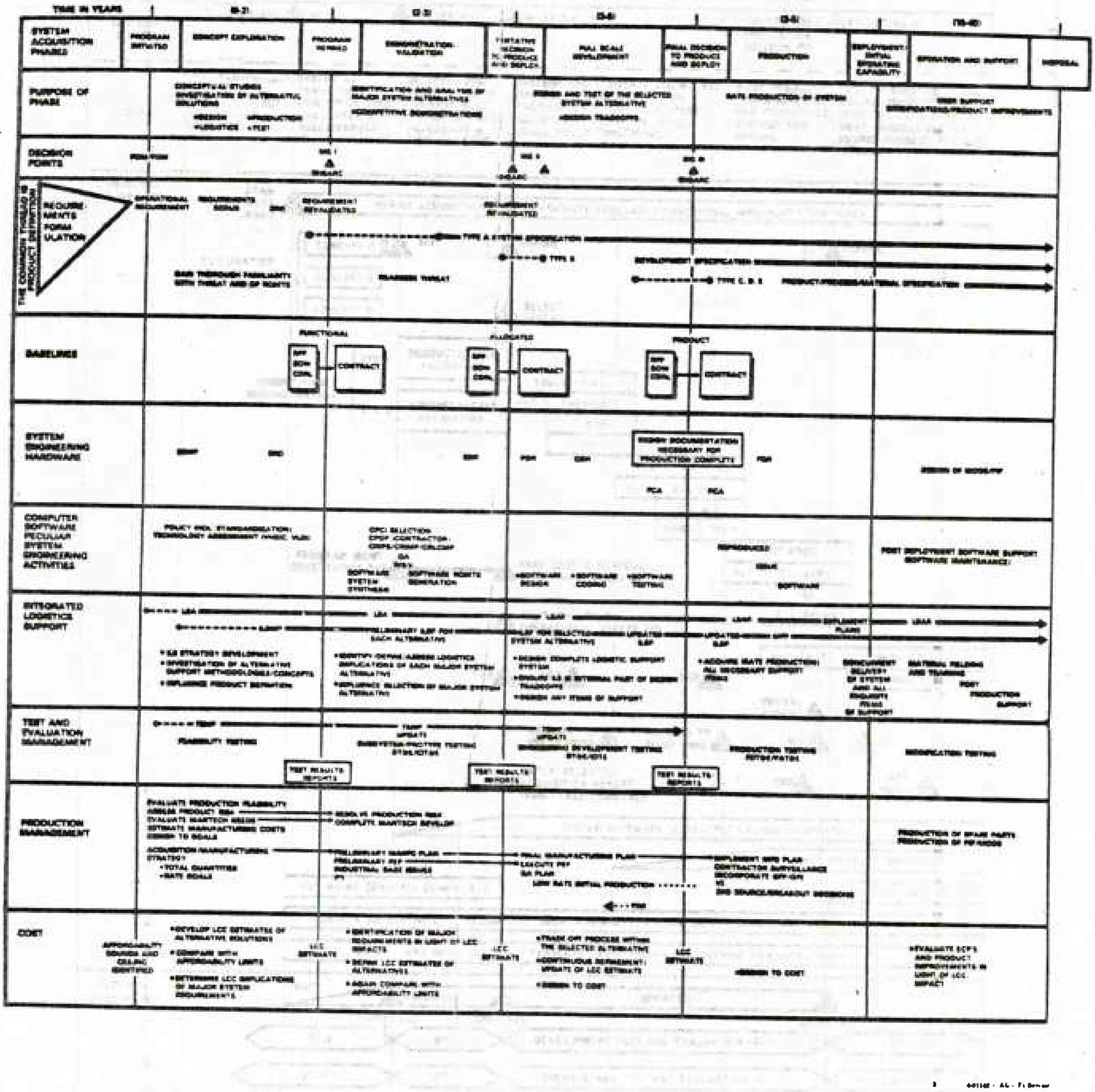
The system acquisition process can be thought of as having six phases:

- the Mission Area Analysis,
- the Concept Exploration (CE) Phase,
- the Demonstration and Validation (D&V) Phase,
- the Full Scale Development (FSD) Phase,
- the Production Phase, and
- the Deployment Phase.

This handbook deals primarily with those activities in the four middle phases which can influence the sixth phase.

Exhibit 3-1 summarizes the acquisition life cycle technical activities in the major program areas for a typical major system acquisition, from program initiation to disposal. As can be seen, activities occur in all areas, with certain activities being

ACQUISITION LIFE CYCLE TECHNICAL ACTIVITIES



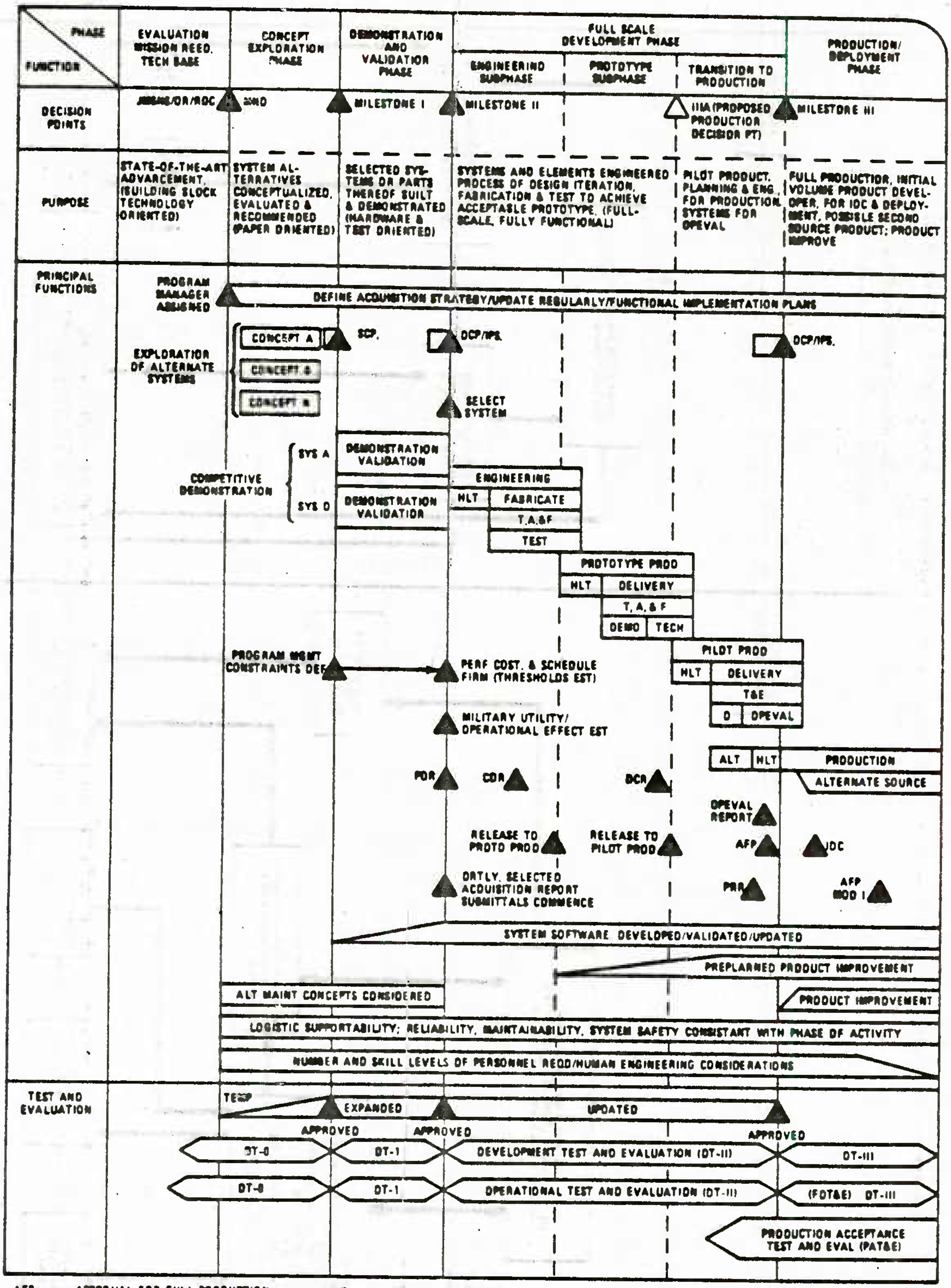
Source: Defense Systems Management College

Exhibit 3-1. SUMMARY OF ACQUISITION TECHNICAL ACTIVITIES

repeated within each phase, specifically those related to milestone decisions. Each of the activities shown on this exhibit represents a set of tasks required to support the activity, marked by initiation and completion milestones, or events. As can be seen in this exhibit, activities in each of the program areas progress through each phase toward a sufficiently complete stage for "the concurrent delivery of system and all requisite items of support." These activities are only generally discussed in this chapter. The activities most directly related to materiel readiness are discussed in Chapter 4.

Exhibit 3-2 gives a summary of the acquisition process from the perspective of the major phase activities relating to system design and testing. The major emphasis in this handbook is on the activities in the Concept Exploration, Demonstration and Validation, and Full Scale Production Phases. These are the phases when design and management decisions relating to materiel readiness may be jeopardized by the imposition of concurrency. While the overlapping of the FSD and Production Phases is when concurrency relating to materiel readiness can have a most significant impact, the decisions on how to manage the risks will be made primarily in FSD. Where appropriate, however, Production Phase activities will be discussed.

The Mission Area Analysis determines the initial requirement for a new system, or the need to modify an existing system. Based on this analysis, a number of documents are produced including the two key ones discussed below:



AFP - APPROVAL FOR FULL PRODUCTION
ALT - ADMINISTRATIVE LEAD TIME
CDR - CRITICAL DESIGN REVIEW
DCP/IPS - DECISION COORDINATED PAPER/ INTEGRATED PROGRAM SUMMARY
DCR - DESIGN CERTIFICATION REVIEW
HLT - HARDWARE LEAD TIME
IOC - INITIAL OPERATIONAL CAPABILITY
JMSNS - JUSTIFICATION FOR MAJOR SYSTEM NEW START
MND - MISSION NEED DETERMINATION
PDR - PRELIMINARY DESIGN REVIEW
PRR - PRODUCTION READINESS REVIEW
Q - PRODUCT QUALIFICATION
T, A, & F - TEST, ANALYZE AND FIX
TEMP - TEST AND EVALUATION MASTER PLAN

Source: Navy Program Manager's Guide, P-9494, Naval Material Command, July 1983

Exhibit 3-2. SUMMARY OVERVIEW OF THE ACQUISITION PROCESS

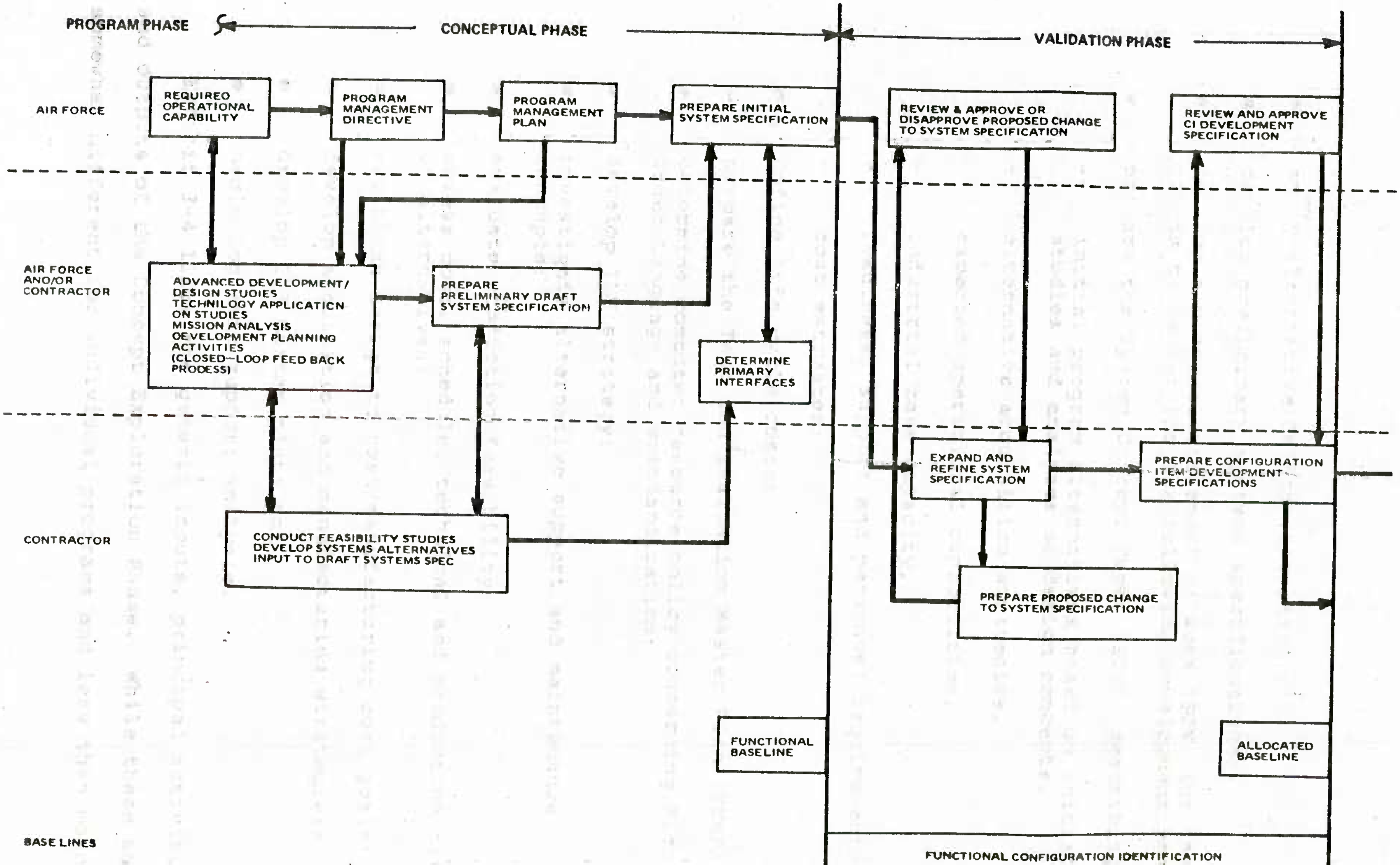
- the Justification for Major System New Start (JMSNS), the statement of the circumstances for requiring the new or modified system; and
- the Program Decision Memorandum (PDM), the authorization to initiate the program.

The SECDEF approval of the Program Objective Memorandum (POM), of which the JMSNS is part, and the signing of the PDM initiates the first of the four developmental phases: Concept Exploration. These phases involve sequences of activities performed by various organizations in specific functional areas. An example of such a set of activities is shown in Exhibits 3-3A and 3-3B. Shown are the major activities involving the Air Force and the contractor in performing the Systems Engineering and Configuration Management functions.

The focus of each phase is to develop a more refined description of the system to be developed. These descriptions of requirements are called baselines and the specifications relating to the baseline are the major focus of the Systems Engineering/Configuration Management Functions. Most of the design-related, versus management-related, activities are focused toward developing the baselines and specifications. This includes not only the hardware specifications, but also baseline descriptions of the software. (These are discussed in greater detail in Chapter 4.)

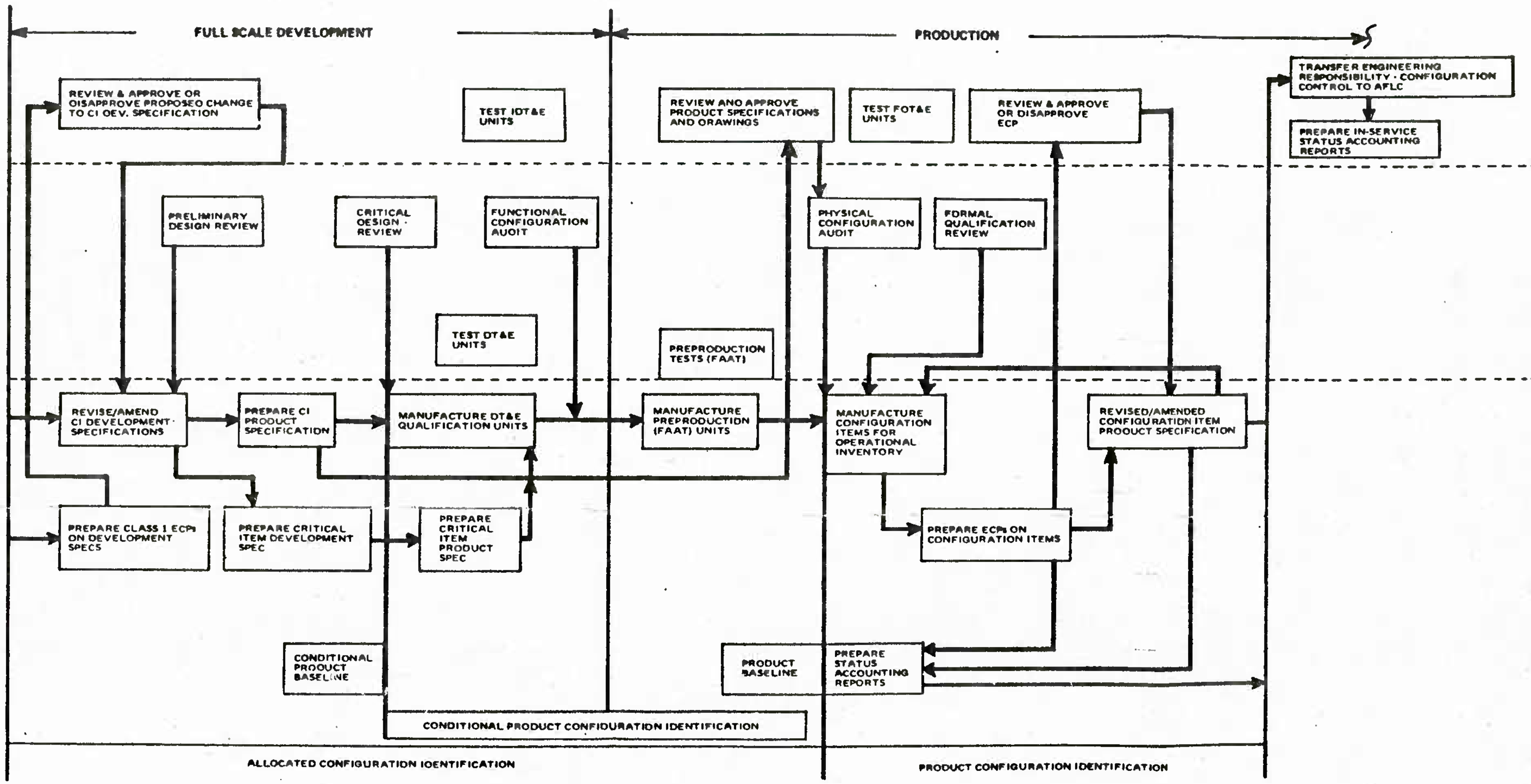
The Concept Exploration Phase activities concentrate on exploring the various concepts open to the Air Force to fulfill the need stated in the JMSNS. These activities include the following:

- validate the Required Operational Capability (ROC);



Source: Program Management Handbook, Deputy for Armament Systems, Armament Division, Eglin AFB, FL, December 1980

Exhibit 3-3A. INTERRELATIONSHIPS BETWEEN SYSTEMS ENGINEERING AND CONFIGURATION MANAGEMENT: CONCEPTUAL AND VALIDATION PHASE

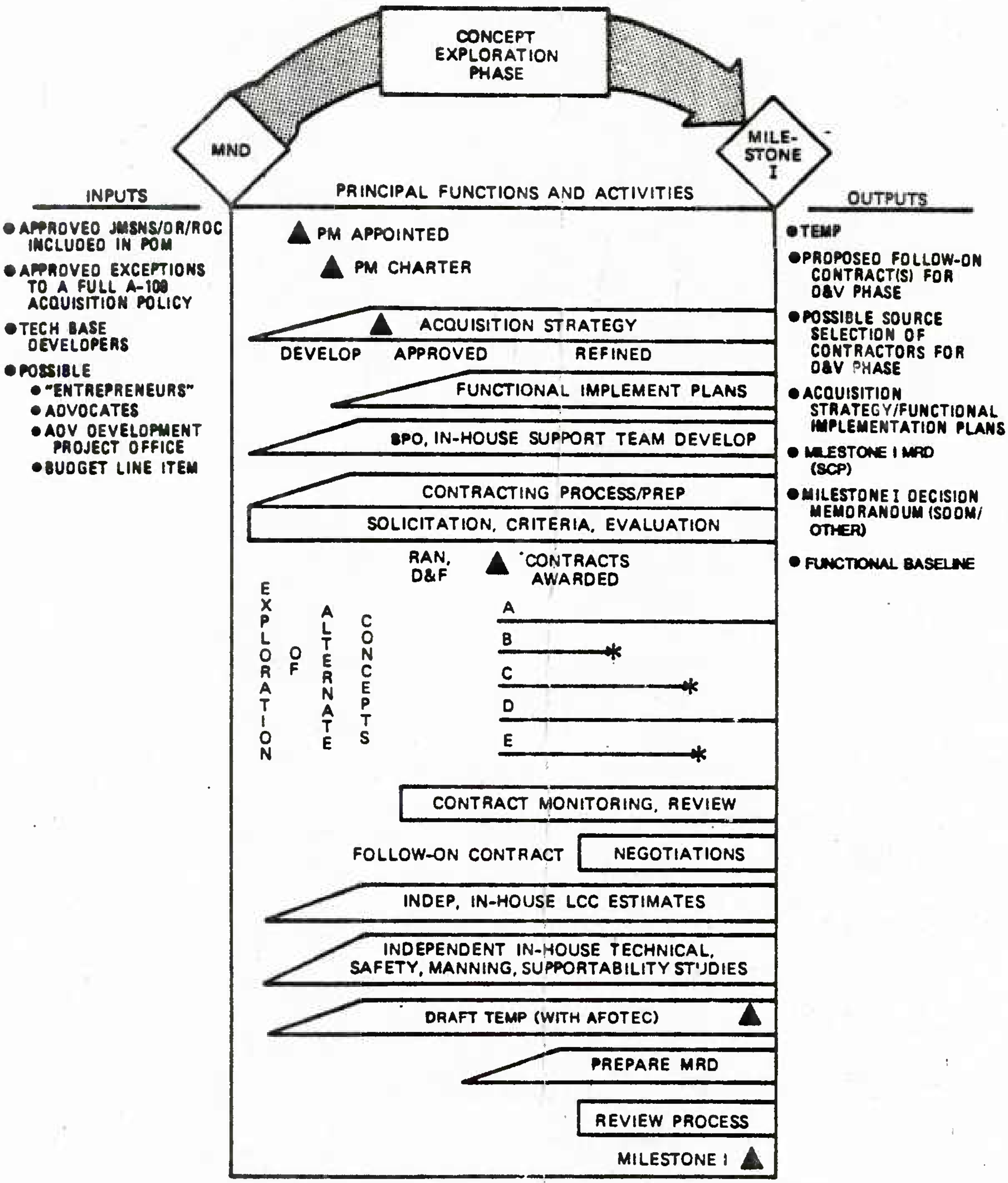


Source: <u>Program Management Handbook</u>, Deputy for Armament Systems, Armament Division, Eglin AFB, FL, December 1980

Exhibit 3-3B. INTERRELATIONSHIPS BETWEEN SYSTEMS ENGINEERING AND CONFIGURATION MANAGEMENT: FULL SCALE DEVELOPMENT AND PRODUCTION PHASE

- study alternative design concepts;
- develop preliminary systems specifications;
- develop a proposed statement of work (SON) for the contracts to be let for the following development phase;
- prepare the System Concept Paper (SCP), describing:
  - initial program alternatives based on initial studies and analyses of design concepts,
  - alternative acquisition strategies,
  - expected operational capabilities,
  - industrial base capacity,
  - readiness, support and personnel requirements, and
  - cost estimates;
- define life cycle costs;
- prepare the Test and Evaluation Master Plan (TEMP);
- determine computer resource policy concerning High Order Language and standardization;
- develop ILS strategy;
- investigate alternative support and maintenance concepts;
- evaluate production feasibility;
- assess cost, schedule, technical and production risks of alternatives;
- establish design to cost/manufacturing cost goals;
- develop acquisition and manufacturing strategies;
- develop ILS master plan; and
- begin logistic support analysis.

Exhibit 3-4 lists the generic inputs, principal activities and outputs of the Concept Exploration Phase. While these may be somewhat different for individual programs and less than major



D&V – DEMONSTRATION AND VALIDATION
D&F – DETERMINATION AND FINDING
JMSNS – JUSTIFICATION FOR MAJOR SYSTEM NEW START
MND – MISSION NEED DETERMINATION
MRD – MILESTONE REVIEW DOCUMENTATION
OR – OPERATIONAL REQUIREMENT
PM – PROGRAM MANAGER
RAN – REQUEST FOR AUTHORITY TO NEGOTIATE
ROC – REQUIRED OPERATIONAL CAPABILITY
SCP – SYSTEM CONCEPT PAPER
SPO – SYSTEM PROGRAM OFFICE

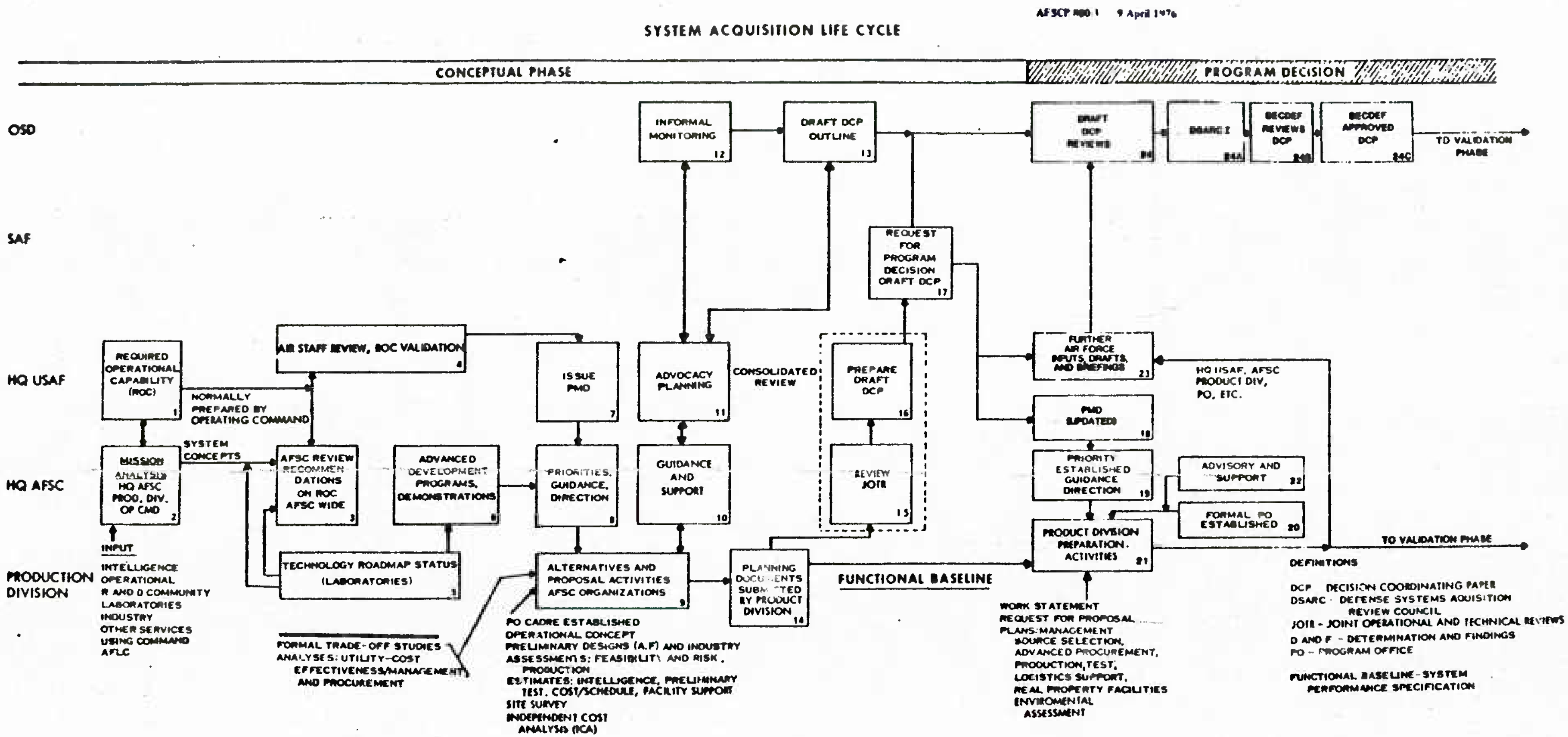
Source: Navy Program Manager's Guide, P-9494, Naval Material Command, July 1983

Exhibit 3-4. INPUTS, PRINCIPAL ACTIVITIES, AND OUTPUTS OF CONCEPT EXPLORATION PHASE

systems, they tend to be applicable for most large programs. Many of the CE Phase activities involve planning, organization and exploration. Exhibit 3-5 is the flow of activities leading from the ROC to the approved DCP, as illustrated in A Guide for Program Management (AFSCP 800-3). While some of these activities may have changed since this pamphlet was published in 1976, the process used today is functionally similar. Appendix C contains an annotated discussion of the block flow of activities in this exhibit as well as the ones for the remaining phases.

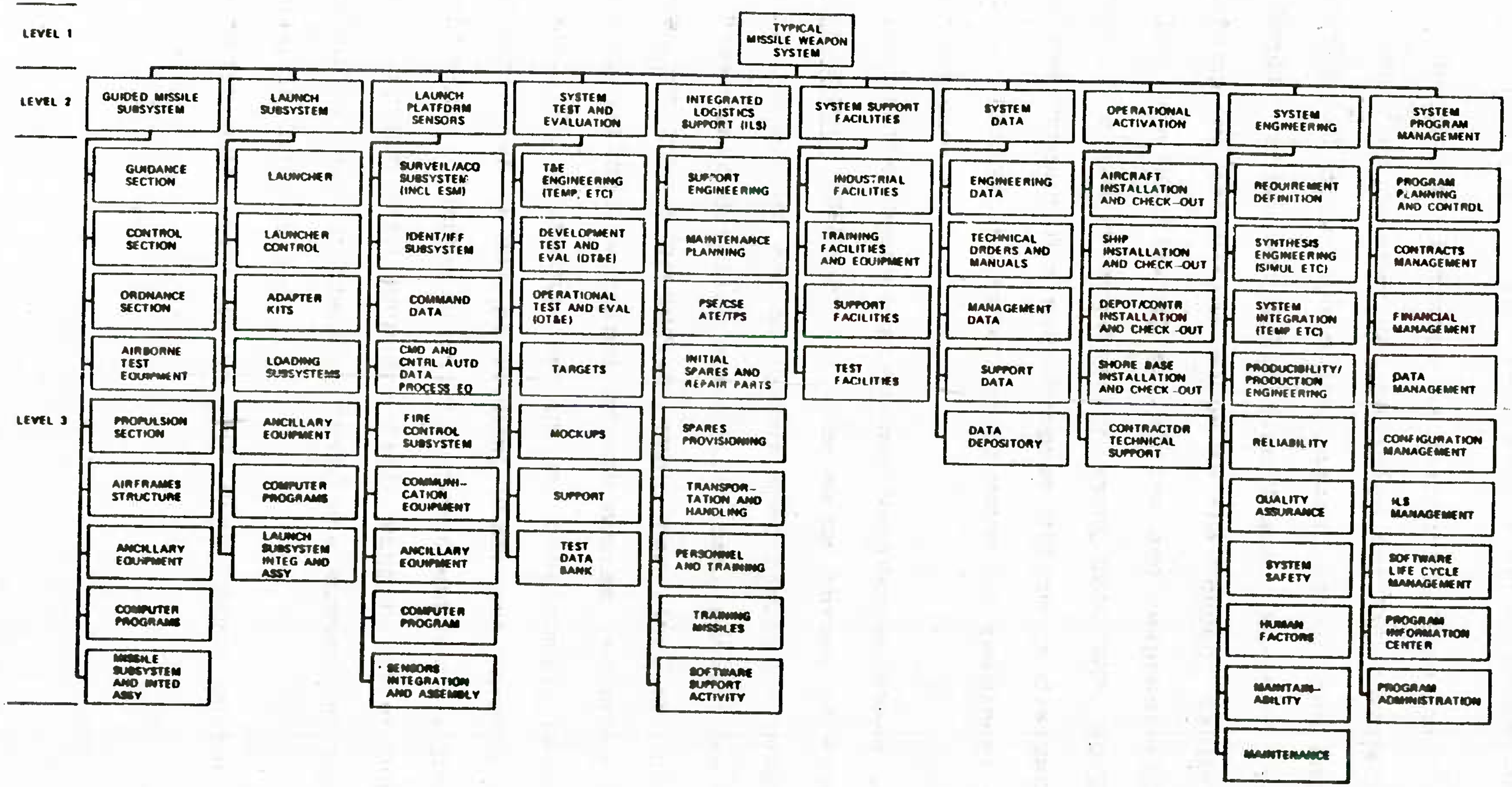
Neither Exhibit 3-4 nor 3-5 represents the activities that occur within the Program Office (PO) in detail. This is primarily due to a fundamental difficulty in representing the "major activities" in what is usually a very complex process. Exhibit 3-6 is an example of a Work Breakdown Structure (WBS) for a missile system. Program activities must be organized to perform the planning, design, review, monitoring, and other functions, for each of the elements in the WBS. Below Level 3 are still more levels of detail, with most large systems having at least six levels of detail. Program activities are frequently tied directly to WBS elements for the purposes of review, monitoring, cost and schedule accounting. A preliminary WBS is drafted as soon as possible in the program, usually using generic structures such as those found in Major System Work Breakdown Structure, MIL-STD-881A.

The Demonstration and Validation (D&V) Phase usually follows the Concept Exploration Phase. This phase is initiated by the SECDEF/SAF Milestone I decision on program refinement. In this



Source: A Guide for Program Management, AFSCP 800-3, Air Force Systems Command, 9 April 1976

Exhibit 3-5. ACTIVITY FLOW IN CONCEPT EXPLORATION PHASE



Source: Navy Program Manager's Guide, P-9494, Naval Material Command, July 1983

Exhibit 3-6. THREE-LEVEL WORK BREAKDOWN STRUCTURE

phase the major design effort defining the specific system characteristics takes place. The following are the major activities taking place:

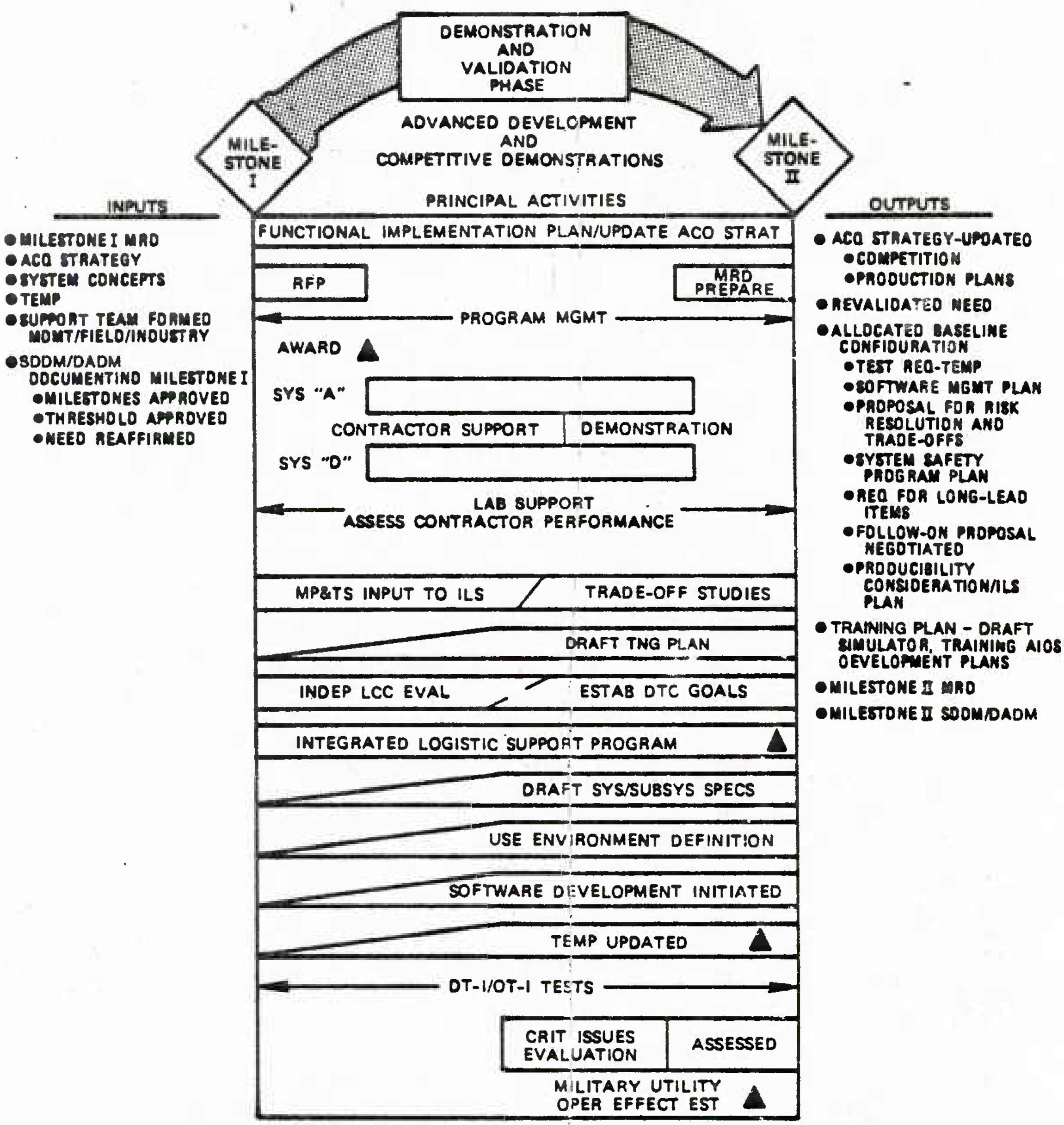
- review and evaluate proposal, and select one or more contractors;
- review system requirements;
- perform trade studies;
- develop system definition;
- determine interface specifications and agreements;
- perform system/subsystem engineering and integration;
- perform specification updating and analysis;
- define configuration control procedures;
- establish drawings release control;
- determine long leadtime items;
- assess production capability;
- establish laboratory relationships;
- update TEMP and determine test support requirements;
- conduct development test and evaluation prototype test;
- prepare program introduction document (PID);
- establish management information system;
- update life cycle cost estimates;
- update risk analyses;
- prepare DSARC II, Decision Coordinating Paper (DCP) and Integrated Program Summary (IPS);
- conduct Preliminary Design Review (PDR);
- select computer program configuration items (CPCI);
- update Computer Resources Integrated Support Plan (CRISP);

- conduct software requirements verification and validation;
- develop preliminary manufacturing plan; and
- develop contractual vehicles for FSD contracts.

Exhibit 3-7 shows the major inputs, activities and outputs of the Demonstration and Validation Phase. Many of these are continuations of activities begun in the Concept Exploration Phase. The general flow of activities and responsibilities in this phase of a system acquisition among OSD, SAF, HQ USAF, HQ AFSC and the Product Division Program Office is discussed in Appendix C. Activities relating to materiel readiness are discussed in Chapter 4.

Following the Demonstration and Validation Phase is the Full Scale Development (FSD) Phase. The major thrust of this phase is to convert the system and subsystem specifications developed in the D&V Phase into detailed specifications, converting the allocated baseline into a production ready baseline, and producing full size operational versions of the system including pilot productions. The planning, design and development tasks initiated and performed in the preceeding phase are largely culminated in the FSD Phase. Emphasis shifts toward ensuring a producable, operational system with adequate field support after deployment. The major activities in the FSD Phase are summarized below, and illustrated in Exhibit 3-8.

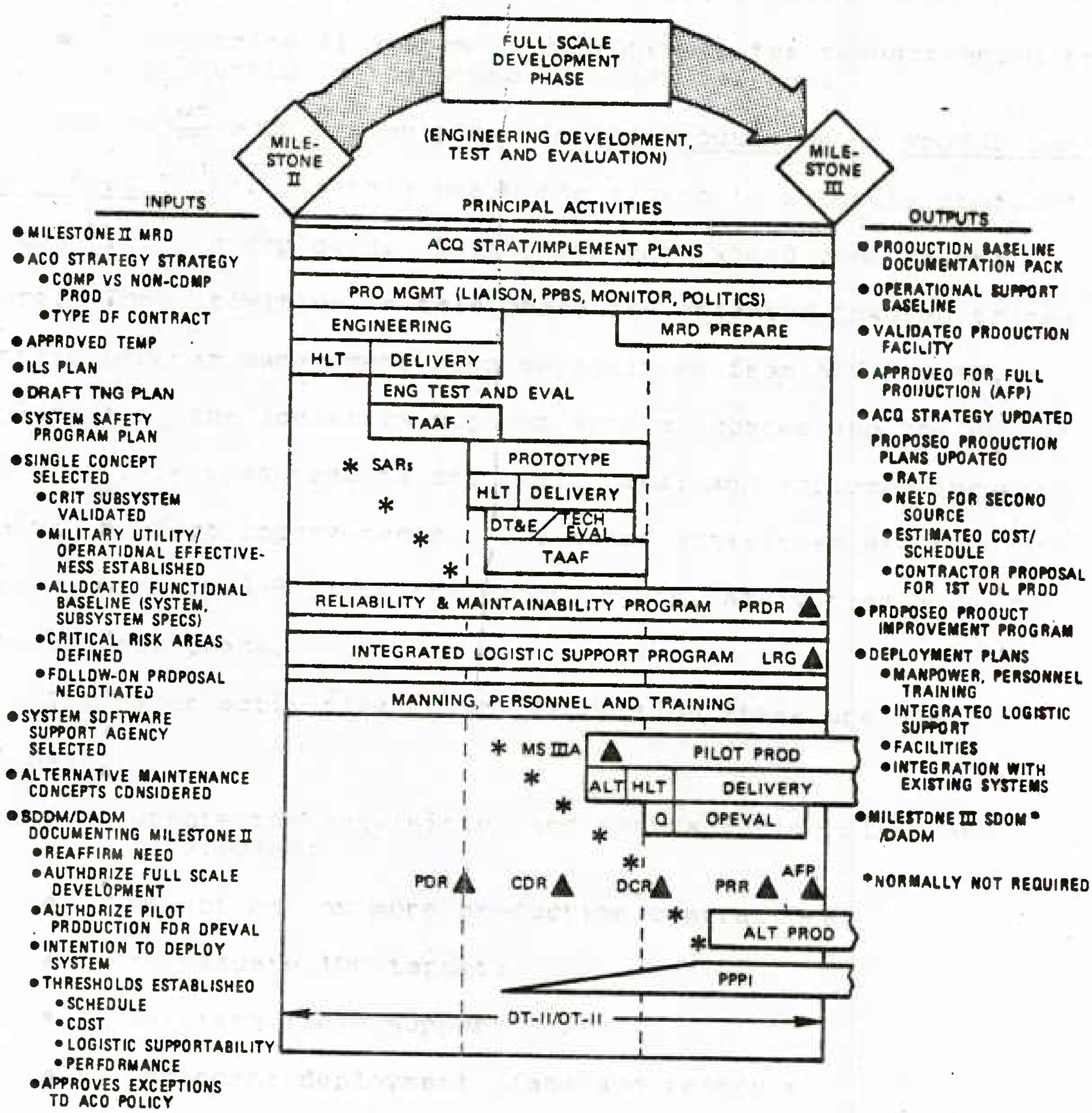
The major activities in the FSD Phase focus on the following:



DADM – DECISION AUTHORITY DECISION MEMORANDUM
DT – DEVELOPMENT TEST
DTC – DESIGN-TO-COST
ILS – INTEGRATED LOGISTIC SUPPORT
LCC – LIFE-CYCLE COST
LRG – LOGISTIC REVIEW GROUP
MND – MISSION NEED DETERMINATION
MP&TS – MANNING, PERSONNEL AND TRAINING
MRD – MILESTONE REVIEW DOCUMENTATION
OT – OPERATIONAL TEST
RFP – REQUEST FOR PROPOSAL
SDDM – SECDEF DECISION MEMORANDUM
SNDM – SECNAV DECISION MEMORANDUM
TEMP – TEST AND EVALUATION MASTER PLAN

Source: Navy Program Manager's Guide, P-9494, Naval Material Command, July 1983

Exhibit 3-7. INPUTS, PRINCIPAL ACTIVITIES AND OUTPUTS OF DEMONSTRATION AND VALIDATION PHASE



AFP – APPROVED FOR FULL PRODUCTION
ALT – ADMINISTRATIVE LEAD TIME
CDR – CRITICAL DESIGN REVIEW
DADM – DECISION AUTHORITY DECISION MEMORANDUM
DCR – DESIGN CERTIFICATION REVIEW
DT&E – DEVELOPMENT TEST AND EVALUATION
HLT – HARDWARE LEAD TIME
LRG – LOGISTIC REVIEW GROUP
MRD – MILESTONE REVIEW DOCUMENTATION
PDR – PRELIMINARY DESIGN REVIEW
PPBS – PLANNING, PROGRAMMING AND BUDGETING SYSTEM
PPPI – PREPLANNED PRODUCT IMPROVEMENT
PRDR – PREPRODUCTION RELIABILITY DESIGN REVIEW
PRR – PRODUCTION READINESS REVIEW
Q – PRODUCT QUALIFICATION
SAR – SELECTED ACQUISITION REPORT (QRTLY)
SDDM – SECDEF DECISION MEMORANDUM
SNDM – SECNAV DECISION MEMORANDUM
TAAF – TEST ANALYZE AND FIX
TEMP – TEST AND EVALUATION MASTER PLAN

Source: Navy Program Manager's Guide, P-9494, Naval Material Command, July 1983

Exhibit 3-8. INPUTS, PRINCIPAL ACTIVITIES AND OUTPUTS OF FULL-SCALE DEVELOPMENT PHASE

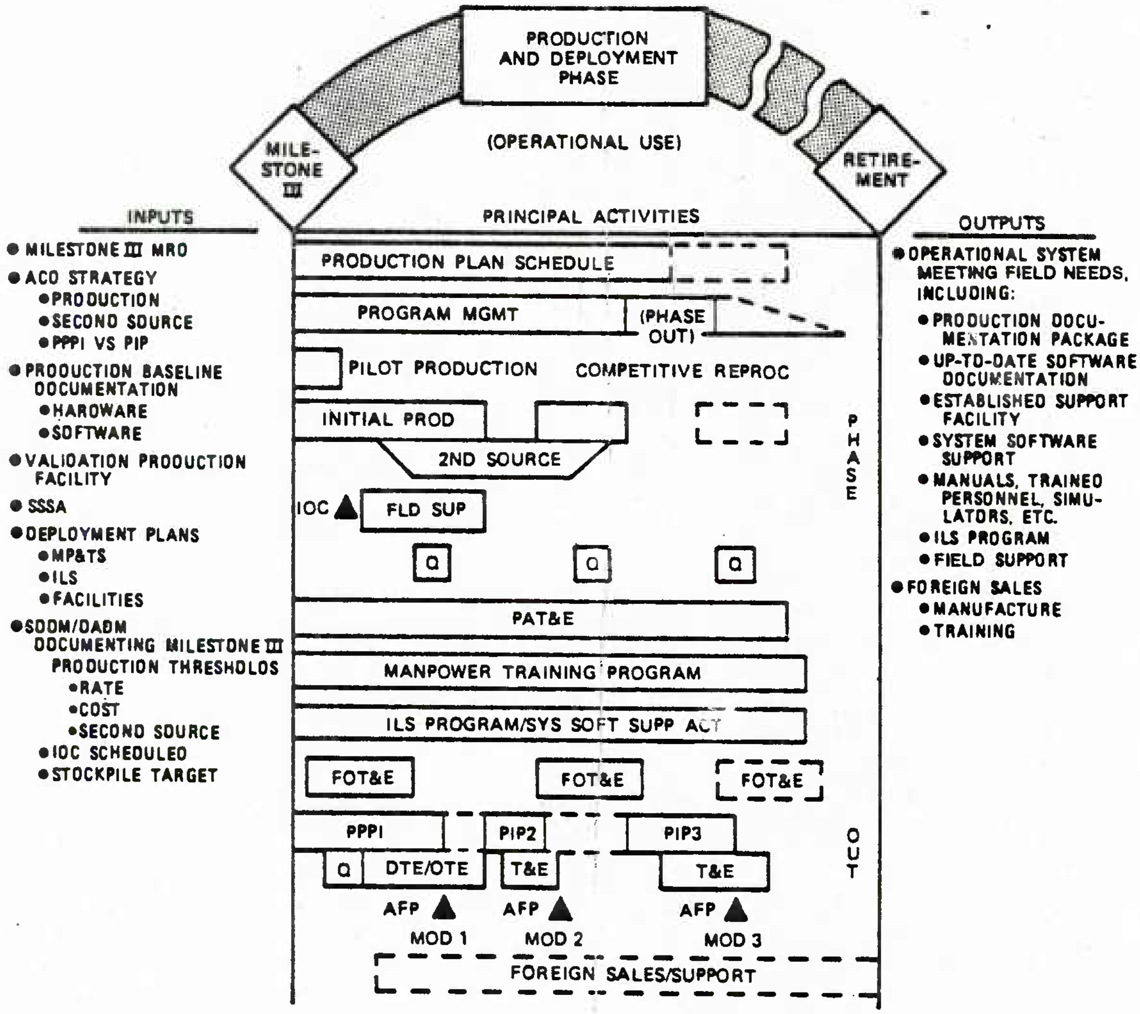
- update the Program Management Directive (PMD) and Procurement Authorization (PA);
- update program documentation;
- review and evaluate proposals and select one or more contractors for FSD contracts;
- perform production readiness review (PRR);
- design complete logistic support system;
- ensure that ILS is part of design trade offs;
- design support equipment;
- update ILSP;
- collect LSA data and maintain LSAR;
- update TEMP;
- perform engineering development testing in Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E);
- finalize manufacturing plan;
- update life cycle cost estimates
- reassess risks;
- review design to cost goals;
- revalidate technical requirements;
- develop Type B specifications;
- complete software design;
- complete software coding;
- complete software testing;
- develop contractual vehicle for Production Contracts;
- continue configuration management;
- develop and finalize technical documentation (orders and manuals);
- plan deployment;
- conduct Critical Design Review (CDR);

- conduct Design Certification Review (DCR); and
- determine if system is appropriate for transitioning to production - Milestone III SAF decision.

The final acquisition phase is the Production or Production/Deployment Phase. In this phase the system is actually produced in quantity and deployed. This phase can extend over several years. The activities in this phase are oriented toward transferring program management responsibilities from AFSC to AFLC; implementing the logistics support system; correcting the design based on late test results and field data; and implementing preplanned product improvements. The major activities are discussed below. Exhibit 3-9 lists the major inputs, activities and outputs of this phase.

The major activities in the Production Phase are the following:

- update the acquisition and manufacturing plans and strategies;
- select one or more production contractors;
- reevaluate IOC target;
- initiate field support;
- implement deployment plans and schedule;
- produce and finalize production documentation package;
- produce and finalize current software package;
- finalize technical documentation;
- train initial cadre of personnel;
- validate training system;
- conduct Physical Configuration Audit (PCA);



AFP – APPROVED FOR FULL PRODUCTION
DADM – DECISION AUTHORITY DECISION MEMORANDUM
DTE – DEVELOPMENT TEST AND EVALUATION
FOT&E – FOLLOW-ON TEST AND EVALUATION
IOC – INITIAL OPERATIONAL CAPABILITY
ILS – INTEGRATED LOGISTIC SUPPORT
MOD – MODIFICATION
MP&TS – MANNING, PERSONNEL AND TRAINING SYSTEMS
MRD – MILESTONE REVIEW DOCUMENTATION
OTE – OPERATIONAL TEST AND EVALUATION
PAT&E – PRODUCTION ACCEPTANCE TEST AND EVALUATION
PIP – PRODUCT IMPROVEMENT PROGRAM
PPPI – PREPLANNED PRODUCT IMPROVEMENT
Q – PRODUCT QUALIFICATION
SDDM – SECDEF DECISION MEMORANDUM
SSSA – SYSTEM SOFTWARE SUPPORT ACTIVITY
T&E – TEST AND EVALUATION

Source: Navy Program Manager's Guide, P-9494, Naval Material Command, July 1983

Exhibit 3-9. INPUTS, PRINCIPAL ACTIVITIES AND OUTPUTS OF PRODUCTION AND DEPLOYMENT PHASE

- conduct final operational test and evaluation;
- continue implementation of change orders;
- implement P^3I program;
- verify and maintain system design and production specifications;
- deliver system and support system;
- transfer program management responsibility from AFSC to AFLC; and
- develop second production source, as required.

This has been intended as a very cursory review of the major system acquisition phase activities. The reader should consult the various regulations and guides referenced here and in Appendix A for detailed discussions on these activities. Additional detail regarding these activities is also given in Appendix C.

TYPICAL ACQUISITION PROGRAM OFFICE ORGANIZATION

In addition to the acquisition activities, there is another side to the acquisition process: the program office (PO). These are the people who perform the acquisition activities. The program office can be thought of including not only the Air Force personnel in an AFSC Product Division, but also the civilian contractor performing the design, development and production responsibilities.

In this part of the chapter the basic structure of a "typical" program office is briefly discussed. As with the preceeding overview of acquisition activities, only a very summary

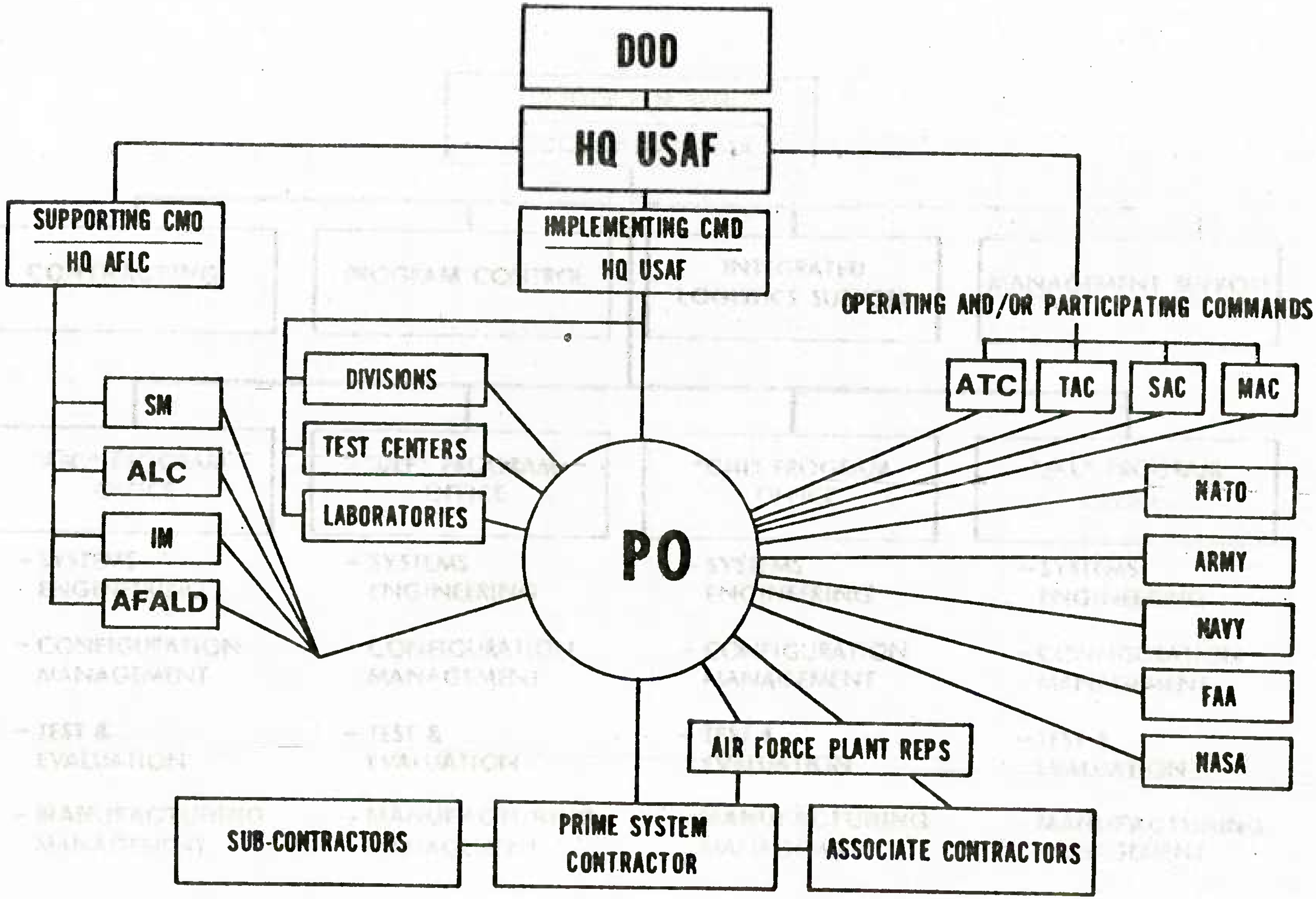
consideration of the organizations generally found in a PO is given here. This is for two reasons:

- There are numerous guides and studies available which discuss PO organization and responsibilities.
- The size and structure of the PO must be tailored to the specific program.

This part of the chapter is primarily intended to give the reader an orientation in order to understand the discussions of materiel readiness-related activities in Chapter 4.

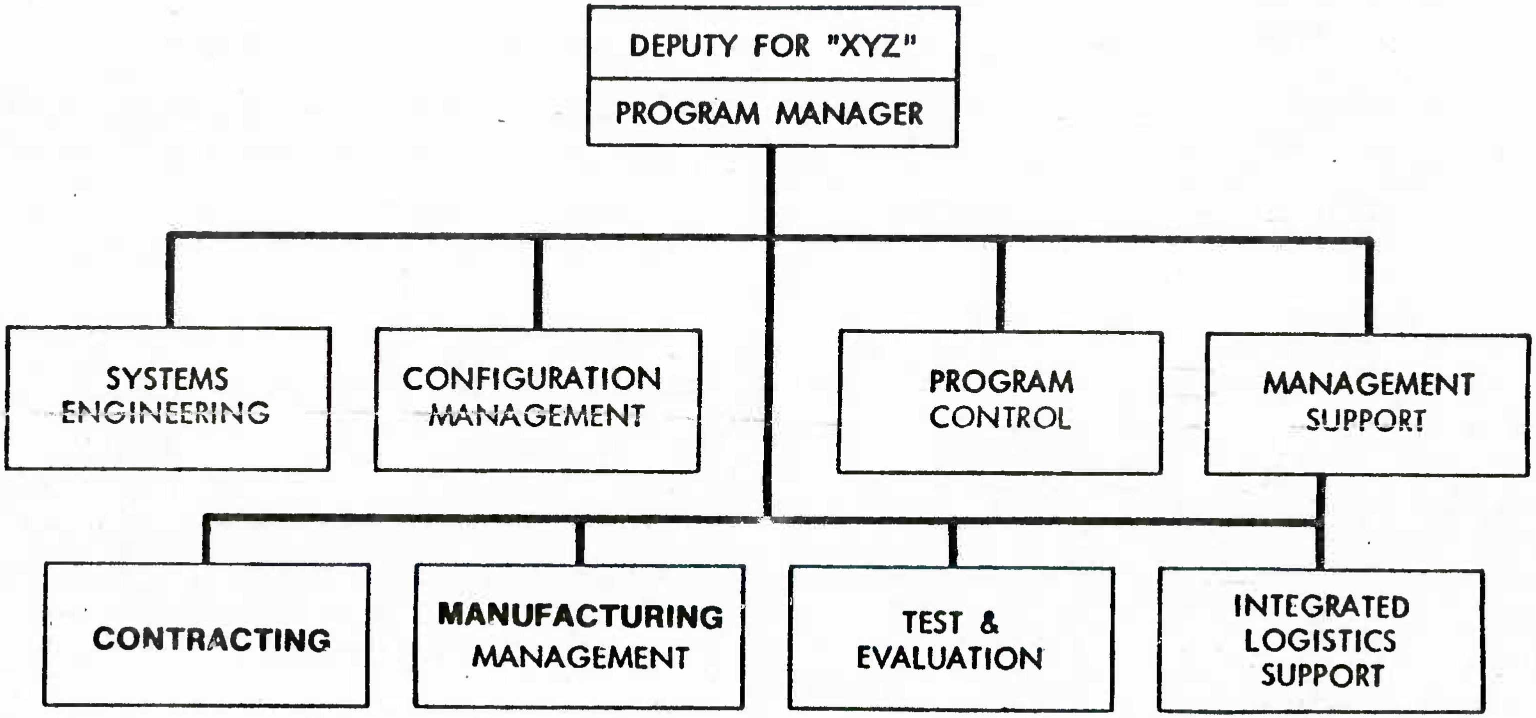
Exhibit 3-10 gives an indication of the various groups with which the PO must interact. The PO is usually divided into a number of functional areas which may be called Directorates, Divisions, or Branches. These groups are responsible for managing and performing the tasks identified in the various plans.

There are two basic types of POs: the single program PO which may be organized to acquire a major or super program (e.g., F-16, B-1B, Peacekeeper programs); and the "basket" PO which is organized to develop and acquire multiple systems of the same type. Exhibits 3-11 and 3-12 illustrate the structural differences in PO organization between a single program and multiple program PO. As can be seen, the same functions are shown for each type of PO, however, some functions are shared among the programs in the multiple program PO, while others are duplicated for each program. Exhibits 3-13 and 3-14 show examples of variations on the single program PO structure. Exhibit 3-13 depicts the Ballistic Missile Office Structure and Exhibit 3-14 illustrates the general structure of the F-16 PO. Both illustrate the



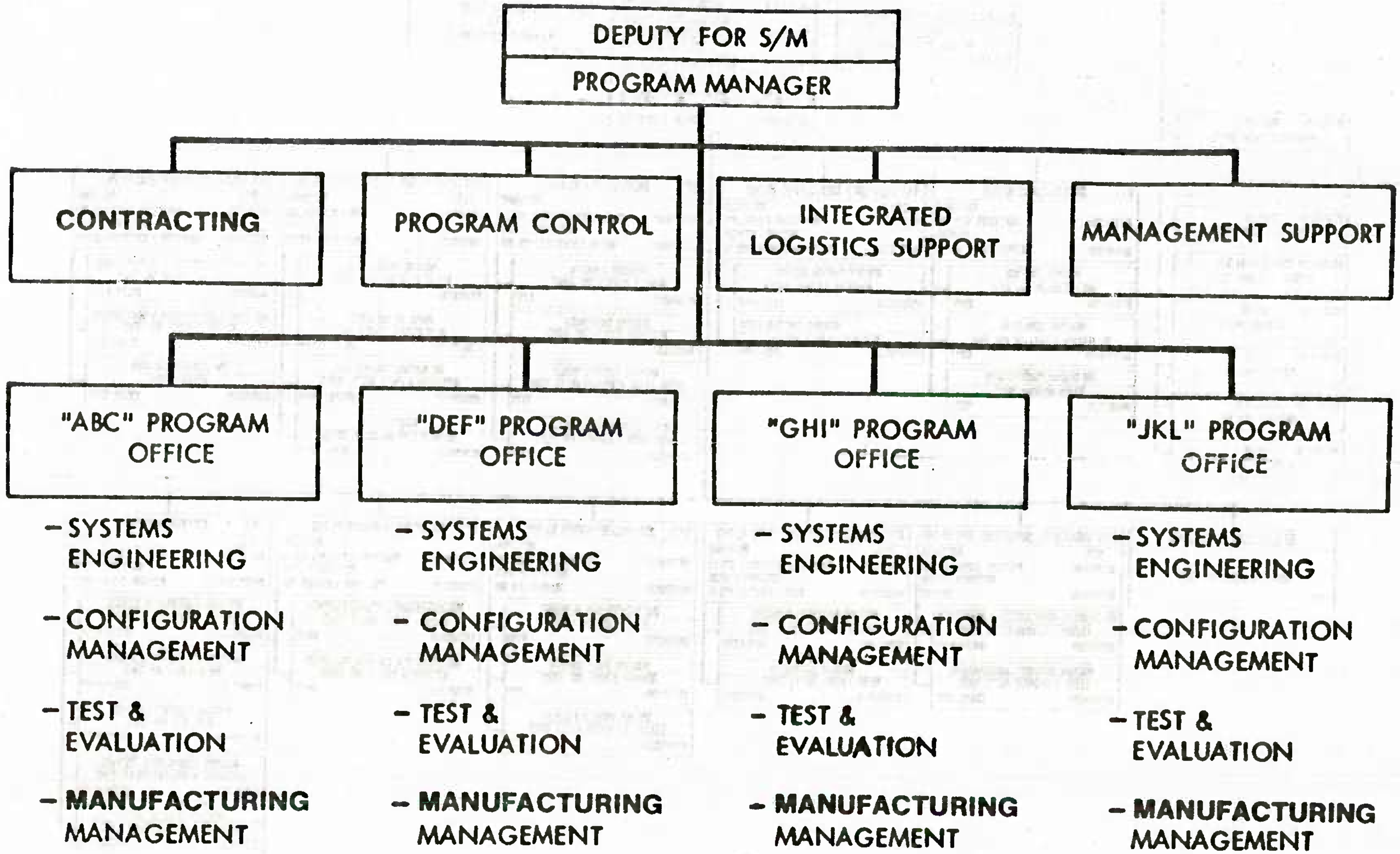
Source: Weapon System Acquisition Guide, (Air Command and Staff College, May 1981)

Exhibit 3-10. PROGRAM OFFICE RELATIONSHIPS



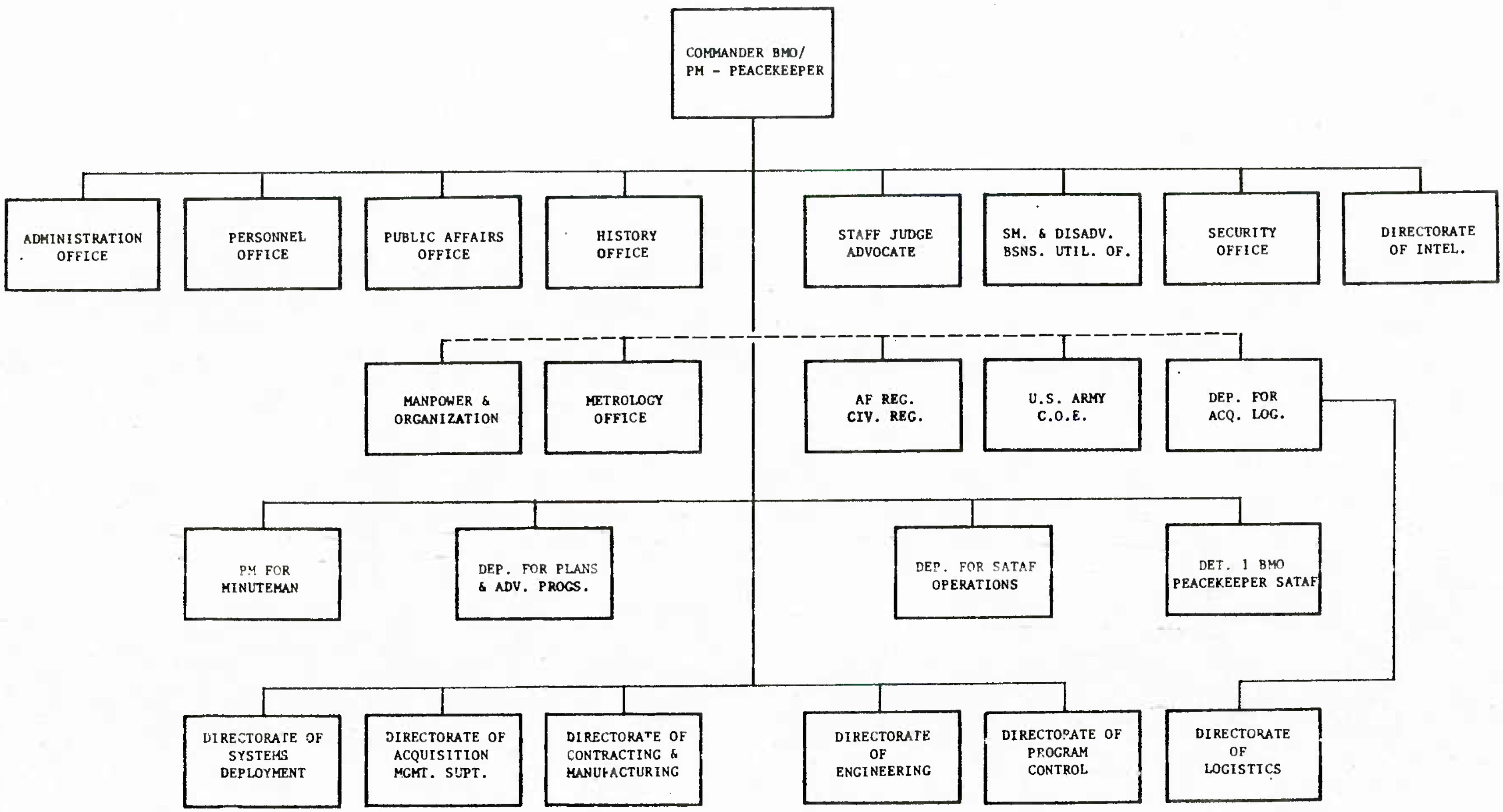
Source: <u>Weapon System Acquisition Guide</u>, (Air Command and Staff College, May 1981)

Exhibit 3-11. TYPICAL SINGLE PROGRAM PO



Source: Weapon System Acquisition Guide, (Air Command and Staff College, May 1981)

Exhibit 3-12. TYPICAL MULTIPLE PROGRAM PO



Source: Engineering Project Officers' Manual, Ballistic Missile Office, May 1983

Exhibit 3-13. BALLISTIC MISSILE OFFICE ORGANIZATION

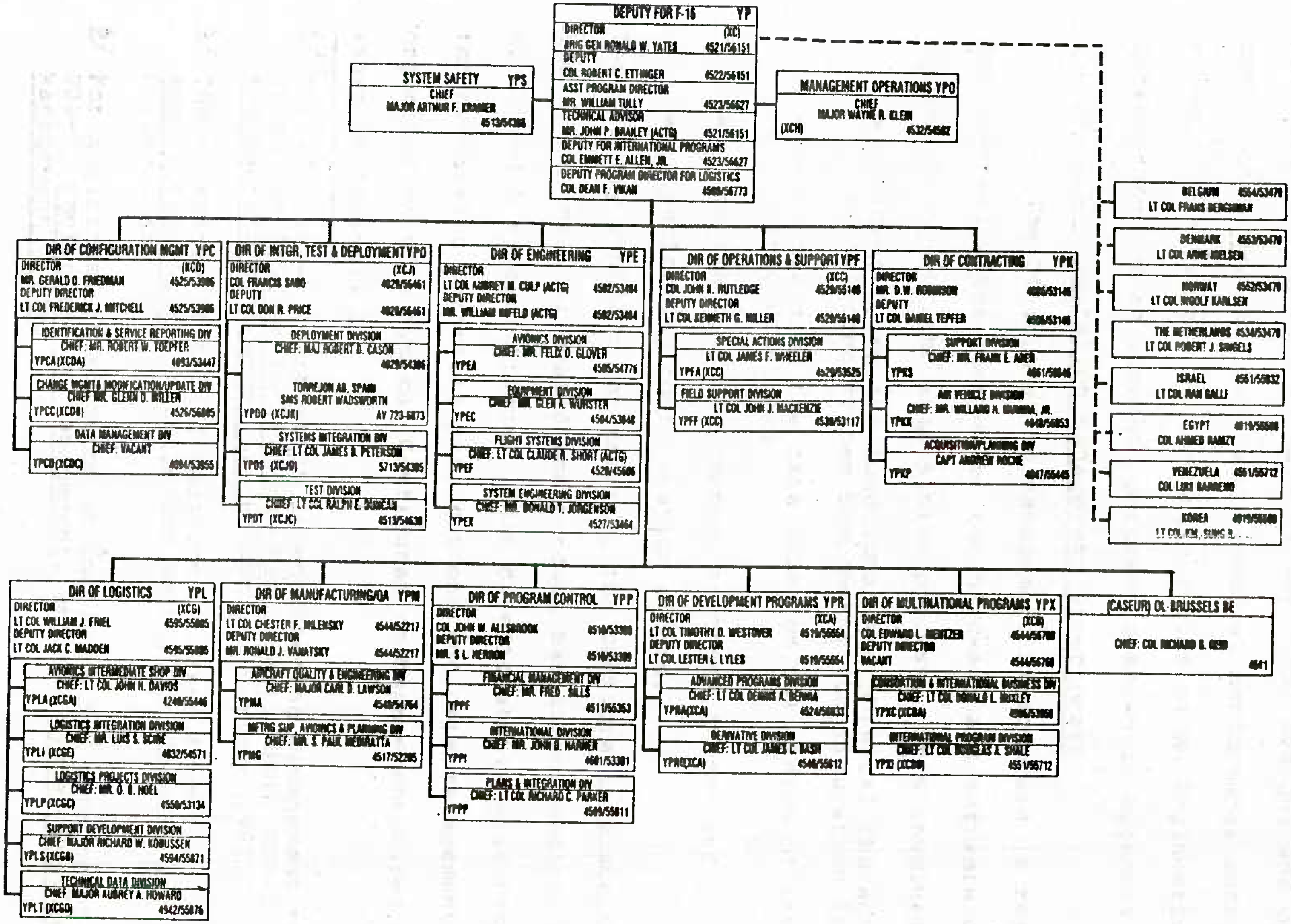


Exhibit 3-14. F-16 SPO ORGANIZATION CHART

organizational tailoring of PO organizations to fit the needs of the program. The BMO organization includes many groups not usually separately identified in a PO. The multinational nature of the F-16 program is indicated by the Multinational Programs Directorate and International Finance Division.

1. Systems Engineering Directorate[3]

The Systems Engineering Directorate is the organization within the PO primarily responsible for the systems engineering and technical design for the system. This directorate manages the in-house engineering activities and the contractor engineering activities including system and subsystem integration and specialty engineering.

The Systems Engineering Directorate is also responsible for:

- conducting system analysis and trade off studies;
- approving performance specifications;
- assisting in technical order validation and verification;
- conducting technical reviews;
- assisting in test and evaluation efforts, particularly developmental test and evaluation; and
- participating in the Test Planning Working Group (TPWG), Computer Resources Working Group (CRWG) and Interface Control Working Group (ICWG).

The overall engineering management task involves defining system performance parameters and configurations; planning control of

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3/ The major portion of this discussion has been adapted from the Weapon System Acquisition Guide, (Huffman, Lozito and Snyder, Air Command and Staff College, May 1981).

technical program tasks; integration of the results of the specialty engineering efforts in the total design; and optimizing cost, schedule, readiness and technical performance considerations.[4] An example of the organization of an Engineering Directorate for an aircraft program is shown in Appendix C.

2. Configuration Management Directorate[5]

The Configuration Management Directorate is responsible for overseeing the control of the hardware and software configuration throughout the acquisition process. This involves:

- identifying the functional and physical characteristics of selected system components (Configuration Items),
- maintaining the data files on the status of the CI characteristics;
- controlling the changes to these items; and
- performing configuration audits.

The primary vehicles for tracking the configrations are through the functional, allocated and product baselines, and the Type A, B, C, and D specifications. This directorate is also responsible for overseeing technical publications and data management.[6] The organization of a typical Configuration Management Directorate is shown in Appendix C.

4/ For additional information in engineering management responsibilities see A Guide for Program Management, AFSCP 800-3, and System Engineering Management Guide, DSMC, 3 October 1983.

5/ The substance of this discussion is taken from the Systems Acquisition Guide, (Runkle and Smith, Air Command and Staff College, May 1978.)

6/ For additional information on configuration management see AFSCP 800-7, Configuration Management, and the System Engineering Management Guide.

3. Program Control Directorate[7/]

The Program Control Directorate is responsible for:

- program planning and programming;
- progress tracking/schedule monitoring;
- maintenance of the master schedules;
- developing the program budget submissions for the PPBS cycle;
- analyzing the financial status of the program;
- coordinating risk analysis results in the program acquisition strategy; and
- developing program forecasts of risks.

The Program Control Directorate usually includes the financial management functions, the personnel and resource planning groups, liaison offices for external groups (Congress, visiting dignitaries, analysts from other organizations, etc.) They maintain oversight of the contractor's cost/schedule control system criteria (C/SCSC) and analyze the reports the contractor produce in response to this requirement. An illustration of the organization of a typical Program Control Directorate is given in Appendix C.

4. Contracting Directorate

The Contracting Directorate is responsible for conducting the activities associated with developing the contractual vehicles for acquiring contractor services, supplies, equipment, support, etc.; participating in the selection of sources, negotiating contracts and administering modifications to contracts. Responsibilities of the Contractoring Directorate include:

7/ The substance of this discussion is taken from the Weapon System Acquisition Guide.

- developing the Request for Proposal (RFP), invitation for Bids (IFB) and Request for Quotes (RFQ);
- developing the determination and findings (D&F);
- determining the type of contract to be let;
- determining the schedule and terms for the contract;
- deciding if the contract should be competed;
- issuing the RFP, IFB or RFQ;
- receiving the proposals in response;
- participating in the source selection process;
- chairing the negotiation team for negotiating the final contract terms;
- approving and executing the signed contract;
- working with the Air Force Plant Representative Office (AFPRO) to ensure that the contractor fulfills the terms of the contract;
- negotiating and adminstrating any contract modifications; and
- evaluating contract impacts of Engineering Change Proposals.

The organization of a typical Contracting Division is given in Appendix C.

5. Manufacturing Management Directorate[8/]

The Manufacturing Management Directorate is responsible for overseeing all manufacturing activities, including developing the manufacturing plan and strategies, producibililty analysis, production planning and control, production demonstration and testing, manufacturing method development, and overseeing of

8/ The substance of this discussion is based on information contained in Department of Defense Manufacturing Management Handbook for Program Managers, first edition, DSMC, January 1982.

fabrication, assembly, installation, checkout, scheduling and program surveillance.

The manufacturing management process has three major parts: planning, analysis, and control. The planning phase considers factors such as:

- materiel acquisition;
- adequacy of the labor force;
- engineering design;
- provisions for sub-contractor support;
- production feasibility;
- producibility of the engineering design;
- new manufacturing processes, facilities, tools and test equipment; and
- cost control during design.

The analysis phase focuses on the success of the manufacturing process, its efficiency, economy and success in complying with the manufacturing plan. In the design process this activity focuses on analyzing the risks of producing a given design. The analysis aspect of manufacturing management also focuses on coordinating manufacturing impacts of decisions made by the Systems Engineering, Configuration Management, and Program Control Directorates.

The most important aspect of manufacturing management is the conduct of the Production Readiness Review (PRR).

> "The PRR is a formal inspection conducted by the Government (PO with AFPRO support) to verify that the production design, planning, and associated preparations for a system have progressed to the point where a production

> commitment can be made without incurring unacceptable risks of breaching thresholds of schedule, performance, cost, or other established criteria."[9]

The PRR effort spans the FSD Phase and focuses on the manufacturers planning, equipment, resources, methods, etc.

The final manufacturing management phase is control, which focuses on monitoring the manufacturing status through contractor status reports.[10] The basic organization of a Manufacturing Management Directorate is shown in Appendix C.

6. Test and Evaluation Directorate[11]

The Test and Evaluation Directorate is responsible for the overall coordination of the system test and evaluation effort. The main purpose of the T&E effort is to:

- assess and reduce risks;
- evaluate the system's operational effectiveness and suitability; and
- identify system deficiencies.

Test and Evaluation Directorate activities begin early in the CE Phase with the development of the Test and Evaluation Master Plan. They continue through development, initial and final operational test and evaluation. In the Concept Exploration Phase, T&E efforts are focused on assisting in the selection

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9/ Based on information contained in Production Readiness Reviews, DoDI 5000.38, 24 January 1979.

10/ For more information see also Manufacturing Management for Air Force Acquisitions, AFR 800-9, 1 October 1979.

11/ This discussion is based on information in the Weapon System Acquisition Guide.

of alternative concepts. D&V Phase test and evaluation activities involve efforts to minimize design risks; demonstrate technical and operational feasibility; and prototype testing. FSD Phase efforts are oriented toward demonstration that the engineering design is complete; demonstration that the terms of the contract have been complied with; identification and correction of deficiences; and estimation of operational suitability and effectiveness. Production and Deployment test and evaluation activities are intended to evaluate system improvements, corrections and modifications; refine estimates of operational effectiveness and suitability; and evaluate the system under changing environments.

A typical Test and Evaluation Directorate organization for a multiple program PO is shown in Appendix C. For a single program PO, the T&E Directorate may also be responsible for deployment, in which case it may be organized similarly to the F-16 Program Directorate of Deployment and Test. This directorate has three divisions:

- Field Support and Data,
- Deployment, and
- Test Support.

Test and Evaluation activities will be discussed in more detail in Chapter 4.

7. Integrated Logistics Support Directorate[12/]

The Integrated Logistics Support Directorate is the last of the major technical directorates to be discussed in this

[12/] The substance of this discussion is based on information in the Weapon System Acquisition Guide and the System Engineering Management Guide.

chapter. This directorate is responsible for conducting all of the analyses pertaining to the logistics requirements of the system. The ILS Directorate spans both the activities associated with designing the system by AFSC, and the ultimate responsibility of AFLC for supporting the system once fielded.

The ILS Directorate is responsible for developing and performing the activities in the ILS Master Plan (ILSMP or ILSP), conducting the Logistic Support Analysis (LSA) and in developing and maintaining the LSA record (LSAR). Much of this is accomplished in conjunction with the contractor. This covers a broad territory and includes analyses related to all of the major ILS elements, as well as areas of specialty engineering such as reliability and maintainability.

In addition to implementing the ILSP and integrating ILS considerations in systems engineering and development, this directorate also develops and monitors budget inputs; identifies AFLC support requirements; establishes interfaces with the T&E activities to integrate logistics-related test results; and implements the ILS management information system.

The major ILS areas of concern to this directorate are:

- reliability and maintainability interface;
- maintenance planning;
- support equipment;
- supply support;
- packaging, handling and transportation;
- technical data;
- facilities;

- manpower requirements and personnel;
- training, training support and devices;
- logistics support resource funds;
- computer resources support;
- energy management;
- survivability; and
- ILS test and evaluation.

An illustration of the organization of a typical PO ILS Directorate is shown in Appendix C. Specific activities related to logistics are discussed in Chapter 4. Additional information on logistics is also contained in Appendix D.

CHAPTER 4. FACTORS INFLUENCING MATERIEL READINESS

- Requirements Formulation and Baseline Development
- Hardware and Software Design and Development
- Test and Evaluation
- Integrated Logistics Support
- Program Structuring and Management
- Suggested Readings

CHAPTER 4. FACTORS INFLUENCING MATERIEL READINESS

In Chapter 3 the basic activities occurring in each phase of most system acquisitions were reviewed, as was the organization of a typical Program Office (PO). While individual programs may depart from the order or arrangement of these activities, or the organization of the PO, these structures generally apply to the vast majority of systems. At the very least they provide the baseline for system acquisition planning and organization.

The consideration of those factors, or elements, in a program which relate to a system's materiel readiness requires one to look beyond specific activities and organizations to basic functions. It is necessary to consider <u>materiel readiness as an integrated capability to produce an ongoing, reconstitutable ability to perform the required mission when needed</u>. This means expanding on concepts such as calculated operational availability to focus on the comprehensive maintenance and support capability of the system. In the acquisition process this capability is represented largely by the system's Reliability and Maintainability (R&M) and the Integrated Logistic Support (ILS) system.

The system's reliability and maintainability relate to the dependability of the system and the ease of being able to maintain the system. While they are frequently referred to jointly, they represent different design characteristics. System designers must address these different characteristics individually, recognizing that they are separate capabilities.

For example, while system reliability growth is based on the maturing of the system's technology, and can be projected, no techniques are currently available for meaningfully projecting and quantifying improvements in a system's maintainability beyond two years past IOC.

Both reliability and maintainabiity are, however, perceived as largely related to the system's engineering and operational characteristics. By engineering characteristics we mean the design of the system. By operational characteristics we refer to the system's mission profiles, life profile, and operational environment. For the purposes of this discussion the R&M-related characteristics refer to activities in the following areas:

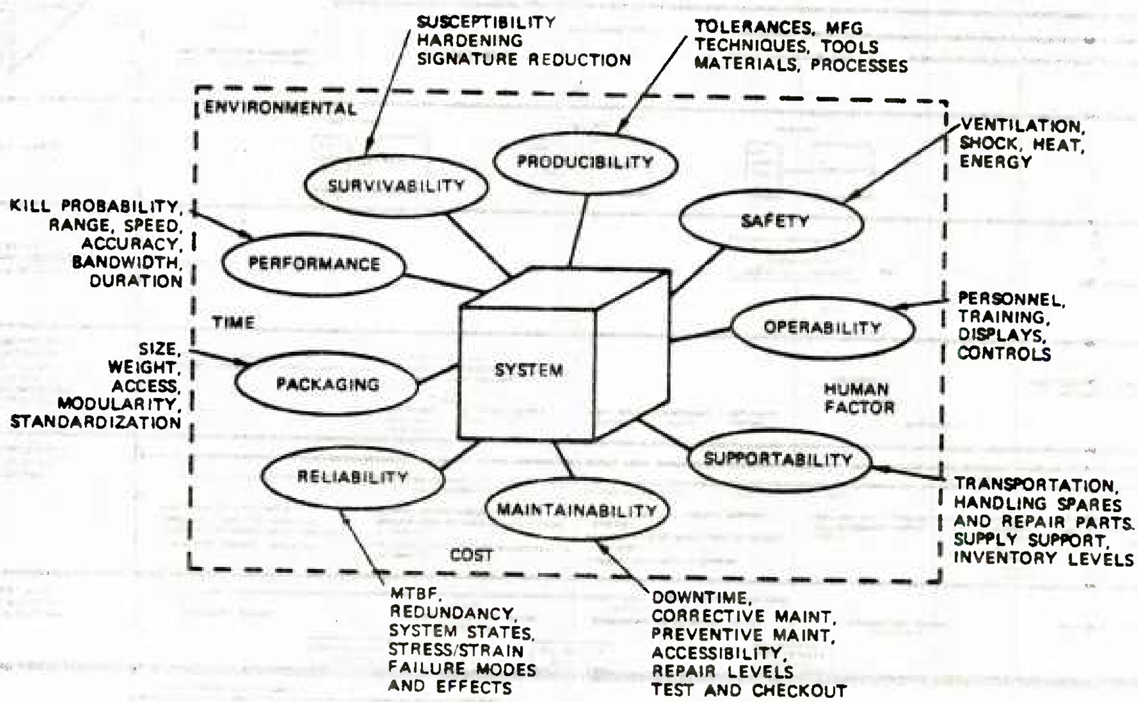
- Requirements Formulation,
- Hardware and Software Design and Development, and
- Test and Evaluation.

Clearly these are somewhat artificially compartmentalized since experts in the field of R&M could argue that many more factors impact the system's R&M. Also, the interactions between these categories are so dynamic as to make such segmentation arguable. The purpose of this chapter is, however, to very generally discuss considerations of those activities that relate to materiel readiness. These discussions cannot, and are not intended to be, comprehensive analyses of materiel readiness drivers. Sources of analysis and additional information on the more specific aspects of this area are referenced at the end of this chapter.

ILS is the collective term for all of the activities involved in assuring that a system, once in the field, can be maintained in an operable state. In the acquisition process it represents the collection of areas or functions which relate to this capability. Logistic Support Analysis (LSA) is the process by which these functions and areas are considered in their own right and also interactively with other system design requirements. Exhibit 4-1 illustrates the nature of the various requirements which drive the system design. The system requirements are represented by specified capabilities regarding:

- Producibility,
- Safety,
- Operability,
- Maintainability,
- Reliability,
- Packaging,
- Performance, and
- Survivability.

These system requirements drive the ultimate system characteristics that directly pertain to system capability. For example, a system's operability relates to, and is influenced by, the quantity and quality of the personnel required to operate and maintain the system. The operability is also related to the adequacy, comprehensiveness and appropriateness of the training those personnel receive; and the ease of use, detail, positioning and placement of the instrument displays and controls of the system.



Source: Navy Program Manager's Guide, NAVMAT P-9494, Naval Materiel Command, July 1983

Exhibit 4-1. SYSTEM REQUIREMENTS AND CHARACTERISTICS RELATIONSHIPS

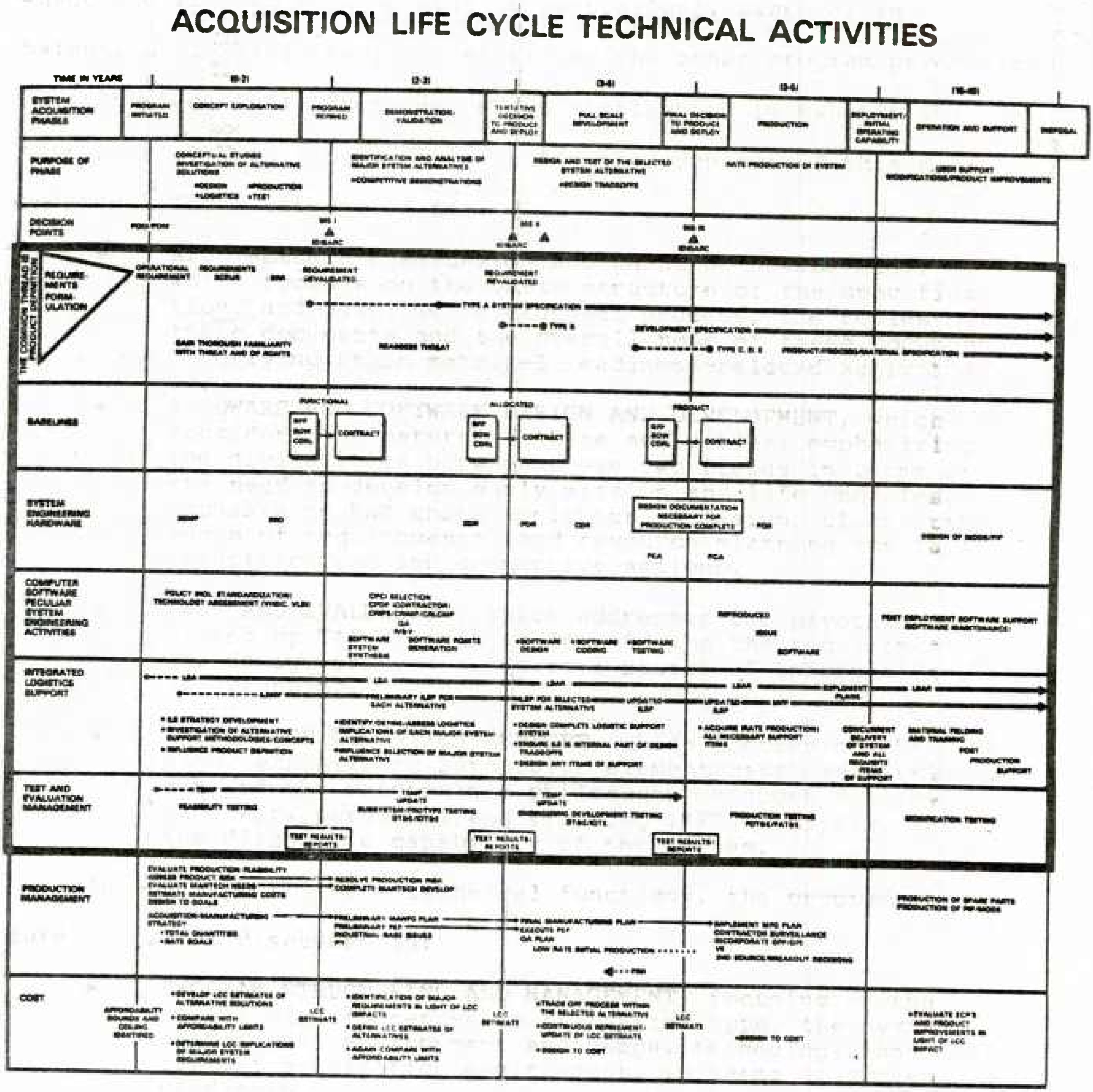
All of these system requirements, and the designing of a system to meet these requirements, is the responsibility of the PO and the associated contractors. However, not all of these requirements relate to a system's materiel readiness.

As noted in Chapter 2, **FACTORS TO CONSIDER**, materiel readiness can be defined in a very broad, generic way, or a very narrow, specific manner (i.e., operational availability.) For the purpose of this handbook, readiness is considered as a function of system reliability, maintainability and logistic supportability. It is also a result of the successful and effective interaction of requirements analysis, system engineering, test and evaluation, configuration management, computer software design, logistic support analysis, and program planning, structuring and control.

Exhibit 4-2 shows an overview of the major acquisition technical activities and functional areas. The activities in the highlighted area are the technical functional areas having the greatest impact on materiel readiness:

- Requirements Formulation,
- Baseline Development,
- Systems Engineering Hardware,
- Computer Software Peculiar System Engineering Activities,
- Integrated Logistic Support, and
- Test and Evaluation Management.

While these areas do not capture all of the potential PO activities or system acquisition factors that can be related to



Source: Defense Systems Management College

Exhibit 4-2. OVERVIEW OF MAJOR ACQUISITION TECHNICAL ACTIVITIES AND FUNCTIONS

the system's ultimate materiel readiness, they represent the major areas of technical concern. Some areas of activity are more integrally involved than others in the technical development and ultimate nature of the system. Others provide administrative, managerial or procurement support, (e.g., source selection, contracting/contract management, budgeting, etc.). While source selection and contracting/contract management will surely impact on the adequacy of the system produced in the end, the terms and characteristics of the contract depend largely on the individual program nature and the circumstances surrounding the acquisition.

Similarly, the budget process is integral to retaining a healthy program, one with sufficient funds to allow for the development of a well designed, logistically supportable system. However, the ultimate budget of a program is determined largely by forces outside of the PO (i.e., SAF, OSD, Congress). Although the development of budget strategies is outside the scope of this handbook, the structuring of a budget profile in terms of early readiness-related analysis is discussed later in this chapter.

This chapter's discussion of materiel readiness-related factors focuses on the activities and functional areas highlighted in Exhibit 4-2. (These areas, as well as others that relate to concurrency impacts on materiel readiness, are discussed in Chapter 5.) These areas are discussed in terms of particular characteristics which make coordinated planning for a balanced approach to system readiness optimization particularly difficult. The emphasis in this chapter is on considering those "factors" (i.e., activities, events or elements) in an acquisition

which the Program Manager must be particularly aware of in balancing materiel readiness risks and the other program priorities.

The technical functional areas highlighted in Exhibit 4-2 have been grouped into categories for the purposes of this discussion. These categories are:

- **REQUIREMENTS FORMULATION AND BASELINE DEVELOPMENT**, which focuses on the basic structure of the specification, and baseline development process, the reviews of these documents and the overall role of these documents in driving other materiel readiness-related activities.

- **HARDWARE AND SOFTWARE DESIGN AND DEVELOPMENT**, which considers the nature of these activities, emphasizing the similarities between these two fields in terms of the need to develop early mission and life profiles, emphasis on R&M characteristics in design, clear statements of requirements, and resource planning for fault identification and corrective actions.

- **TEST AND EVALUATION**, which addresses the pivotal role played by T&E activities in bridging the requirements and design processes and is a source of information for ILS planning.

- **INTEGRATED LOGISTICS SUPPORT**, which focuses on ILS planning, emphasizing particular elements such as development of the maintenance philosophy, support equipment, manpower, personnel and training (MPT) analysis, and the diagnostic capability of the system.

In addition to these technical functions, the program structure itself is discussed in:

- **PROGRAM STRUCTURING AND MANAGEMENT**, focusing on the impact of differences in the system type, the system operational environment and usage, technology, and the current acquisition environment, in terms of system readiness.

REQUIREMENTS FORMULATION AND BASELINE DEVELOPMENT

The cornerstone of system design and acquisition is the description of what the new system is required to do. The

requirement for a new system initially results from the on-going Mission Area Analysis conducted by OSD, OJCS, and the Services. The need to respond to a new threat, to expand capability in a given area, or to capitalize on advancing technology can result in the development of a new system. However, it is a long way from developing a Justification for a Major System New Start (JMSNS) to fielding the system, and along the way the requirements definition of the new system must be refined and described in increasing detail.

Hardware designers, software designers, logisticians, support equipment engineers, reliability and maintainability engineers, Program Managers and program analysts all voice the same thought: The requirements must be continuously reevaluated for reasonableness, necessity, and definition. There are numerous reasons for emphasizing the seriousness of requirements formulation, particularly with respect to materiel readiness.

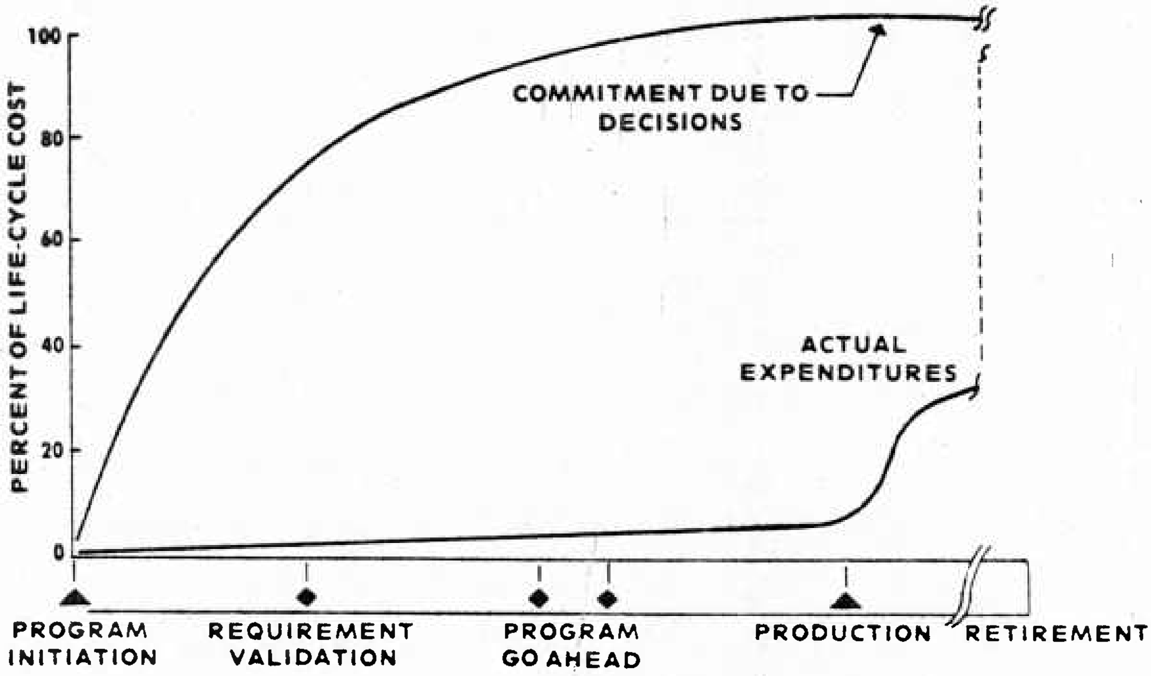
First, the readiness of a system is largely dependent on what the system is intended to do. Readiness relates to the ability to perform the mission the system is intended to accomplish, when, where and how it needs to be accomplished, for the duration of the requirement, under the expected operational conditions. This means that:

- the mission or missions the system must perform must be adequately thought through, effectively designed, and be realistic in terms of performance requirements;
- the frequency with which the system is expected to perform the mission (be operationally available) must be realistic;

- the various environments in which the system is intended to operate must be clearly defined, and expressed in terms meaningful to designers;
- the performance parameters must be realistically defined and considered in light of current and advancing technology;
- the system reliability and maintainability goals and requirements must be determined and clearly and comprehensively described; and
- the operational condition for the deployed system must be critically analyzed not only in terms of the operational missions but the total system life profile.

In addition to being rigorously thought through, clearly defined, and realistically planned, system requirements must also be defined early in the acquisition process. The major reason for this is the impact early design decisions have on the post-deployment system status. Exhibit 4-3 illustrates the life cycle cost expenditure profile of a typical weapon system. As can be seen in this exhibit, over 70% of a system's life cycle costs are fixed by decisions made in the Concept Exploration Phase (i.e., by the Requirement Validation point). Decisions regarding the selection of the concept alternative, the maintenance philosophy, and performance thresholds critically impact the ultimate cost of the system. While approximately one-half to two-thirds of the life cycle costs are incurred after production and deployment, by the time the production decision is made, approximately 95% of the costs have been defined. This means the later the requirements are defined, the costlier it is. This point will be elaborated on later in this chapter.

The second reason for emphasizing requirements formulation as a factor influencing materiel readiness has to do with the



Source: Brabson, G. Dana and Solomond, John P., "Readiness - Coequal," Concepts - Special Issue: The DoD Acquisition Improvement Program, Volume 5, Number 3, Defense Systems Management College, Summer 1982.

Exhibit 4-3. LIFE CYCLE COST EXPENDITURE PROFILE OF A TYPICAL WEAPON SYSTEM

nature of the acquisition phasing. A program cannot stay at the same level of development forever (although it may sometimes seem that way). The investment of government resources must produce progress toward the solution of the problem, or the program will be cancelled. This means the system design must progress in refinement, even if the final requirements have not been delineated.

While the system acquisition process is structured to reduce the possiblity of having just such a situation as lack of definition of requirements (via the milestone reviews), much effort is still expended in the design process before the requirements are resolved. Exhibit 4-4 shows the progressive definition of system specifications and the general relationship of specifications to the system baseline. A specification is "a document, intended primarily for use in procurement, that accurately describes the essential technical requirements for items, materials, or services, including the procedures for determining that the requirements have been met."[1/] Specifications are the single documented statements of what the system is to do. In order to be effective they must be refined from the initial statements of operational need (the user command-generated Statement of Operational Need (SON)/Required Operational Capability (ROC)/JMSNS) developed from Mission Area Analysis.

The first major specification is the Type A, System Specification, the major requirements document produced in the Concept Exploration Phase. This specification includes a description of the technical and mission requirements of the system, allocates

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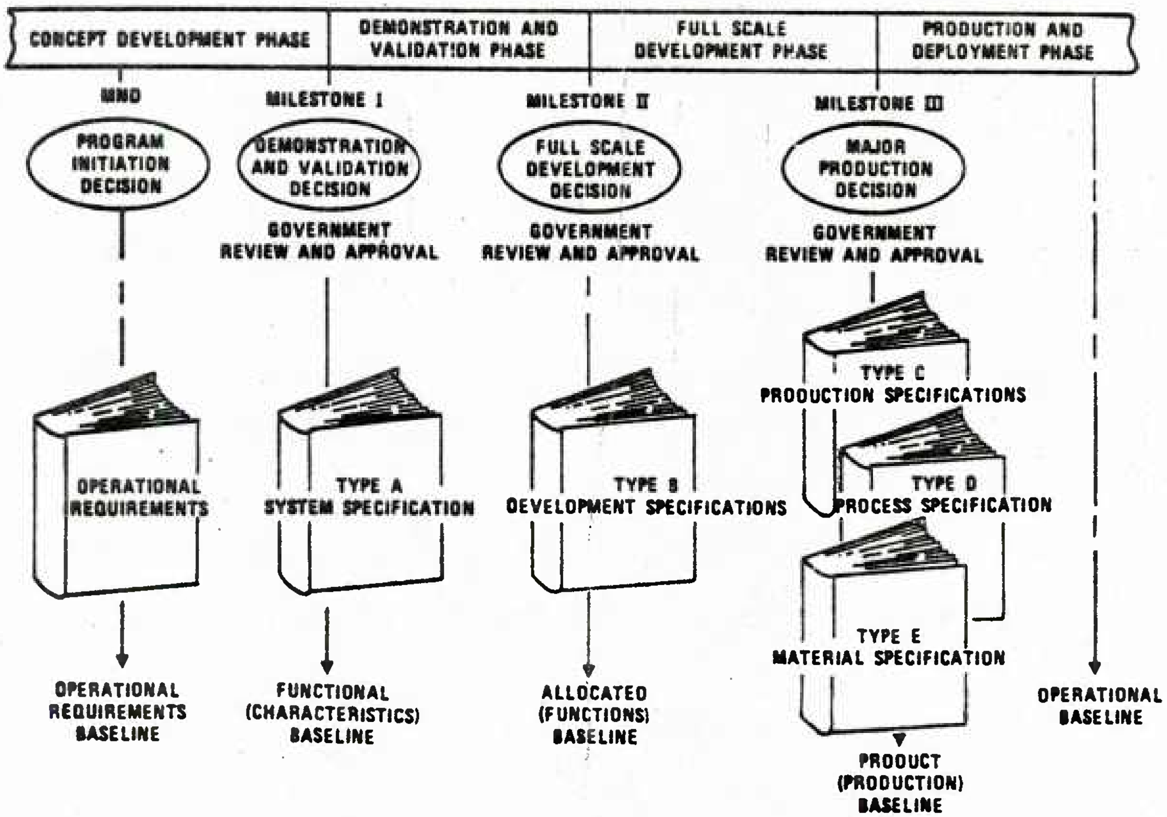
1/ DoDD 4120.3, Defense Standardization and Specification Program.



Source: Navy Program Manager's Guide, NAVMAT P-9494, Naval Materiel Command, July 1983

Exhibit 4-4. PROGRESSIVE DEFINITION OF SYSTEM SPECIFICATIONS

requirements to functional areas or configuration items, and defines the interfaces among the functional areas. All of these are critically important to initiating Demonstration and Validation (D&V) Phase activities. The system specification is used to establish the functional baseline configuration of the system. Similar relationships between specifications and baselines occur in the D&V Phase, Full Scale Development (FSD) Phase and the Production/Deployment Phase. The specification is developed in the preceeding phase, reviewed and accepted. This specification then forms the starting point for the next phase activities, which are directed toward refining and developing a more detailed specification.

The Type B, Development specifications are produced as a result of D&V Phase activities. These specifications are in five sections:

- Type B1: Prime Item Development,
- Type B2: Critical Item Development,
- Type B3: Non-Complex Item Development,
- Type B4: Facility Development, and
- Type B5: Computer Program Development.

In these specifications the system performance and compatibility requirements are updated, the requirements are allocated to each functional area and configuration item (CI), and the objectives of the functional baseline are translated into subsystem and CI performance requirements. These specifications are the basis for the allocated baseline.

The D&V Phase results, the Type B, Developmental Specifications and the allocated baseline form the basis for the FSD Phase activities. In this phase the Type C, Production Specifications are developed, as is the associated product baseline. (Type D, Process Specifications, and Type E, Materiel Specifications are also developed in this phase but are not discussed here because, for the purposes of this handbook, they are less germane to the system's ultimate materiel readiness.) Type C Specifications also have five sections, corresponding to the Type B sections. These are:

- Type C1a: Prime Item Product Function,
- Type C1b: Prime Item Product Fabrication (Part II),
- Type C2a: Critical Item Product Function,
- Type C2b: Critical Item Product Fabrication (Part II),
- Type C3: Non-Complex Item Product Fabrication (Part II),
- Type C4: Inventory Item, and
- Type C5: Computer Program Product (Part II).

The Production Specifications are developed in the FSD Phase and used in the Production Phase as the basis for actually manufacturing the system. The Production Specification provides all of the detail below the system level (i.e., subsystem, configuration item, data for each level of detail in the WBS) necessary to permit economical procurement of the functional elements that, when assembled will produce a system able to function according to the stated requirements. The sections of the Production Specification are divided into two parts: the Functional or Performance

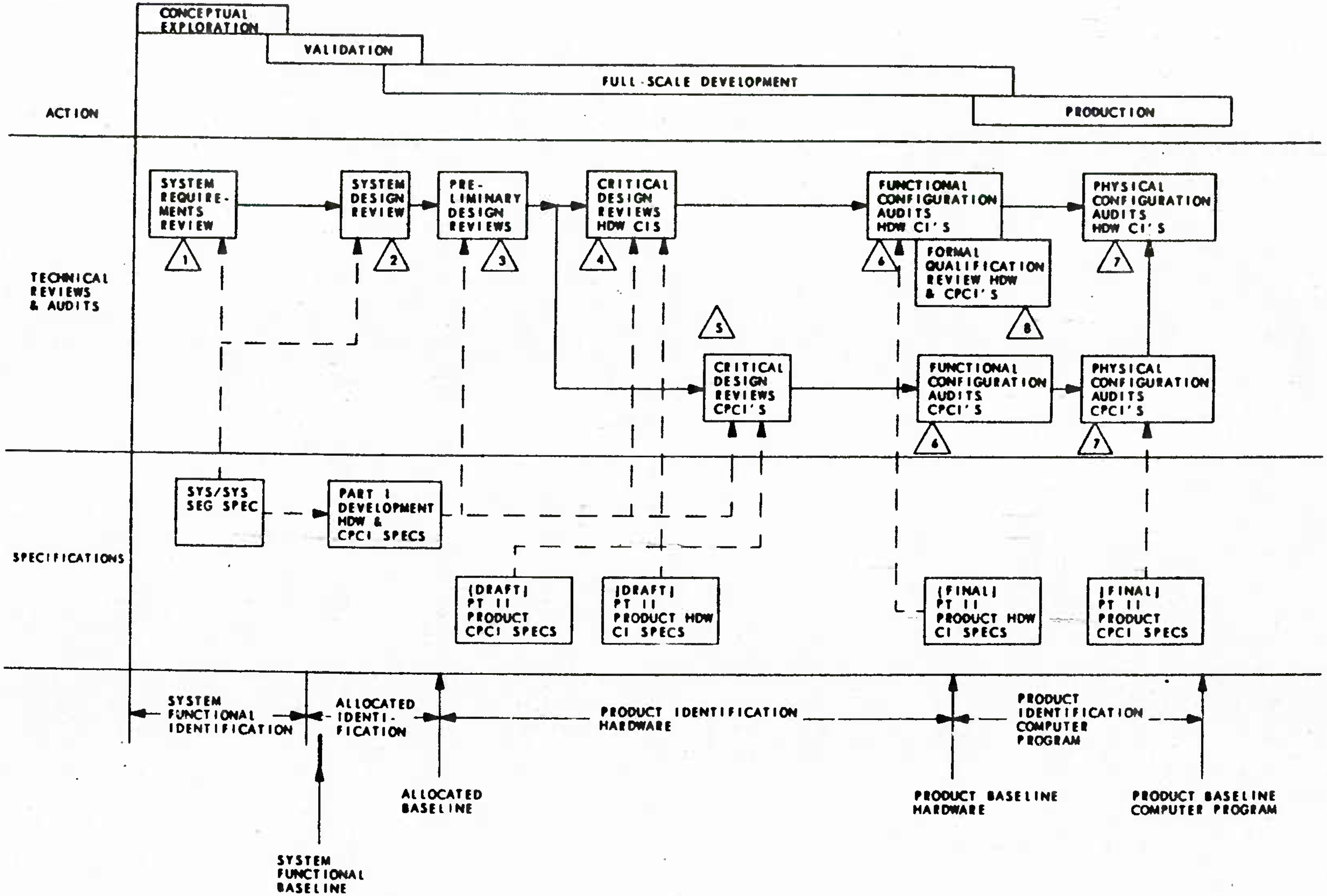
Specification (Type C1a) and the Fabrication or Design Specifications (Types C1b, C2a, C3, C4 and C5).

While the specifications and baselines are clearly closely associated, they fulfill different roles in the program. The specifications translate the Air Force's system requirements into the design, are developed by contractors, reviewed by the Air Force and managed primarily through the systems engineering function. Baselines are the mechanism the Air Force uses to track and control the status of the configuration, through the Configuration Management function.

As can be seen from this brief description of the requirement/specification/baseline development stream, the definition of the system's requirements, and the review of the specifications produced to respond to these requirements must be rigorously monitored. Exhibit 4-5 illustrates the major reviews of the specifications in each phase. The major types of technical reviews or audits in the systems acquisition process are the following:[2]

- The Systems Requirements Review (SRR), in the Concept Exploration Phase, reviews the interpretation of the system requirements in the functional baseline. The review may be performed several times during the CE Phase and in the beginning of the D&V Phase.
- The System Design Review (SDR) reviews the system documentation developed in the D&V Phase, assesses the degree of acomplishment of the System Engineering activities and determines if it is sufficient to proceed into the preliminary design of selected solutions for the allocated baseline. It is performed as a final review of the D&V Phase products or as the initial review in the FSD Phase (for systems not requiring a formal validation phase).

2/ These description have been based on descriptions contained in AFSCP-800-3, <u>A Guide to Program Management</u>.



Source: System Engineering Management Guide, Defense Systems Management College, 30 October 1983

Exhibit 4-5. DESIGN REVIEW AND BASELINE DEVELOPMENT RELATIONSHIP

- The Preliminary Design Reviews (PDR) are multiple reviews conducted throughout the FSD Phase of the status of each configuration item. PDRs evaluate the progress, consistency and technical adequacy of the selected design and test approach and established compatibility with the preliminary design. A successful PDR is necessary for each CI before proceeding into detailed design. However, it does not have to be based on an approved allocated baseline.

- The Critical Design Reviews (CDR) are conducted for each CI and computer program configuration item (CPCI) to determine the acceptability of detail design, performance, and test characteristics depicted in the draft product specification, accompanying drawings, and other engineering documentation. CDRs are conducted in the FSD Phase. For a CPCI, these reviews are performed after the coding is completed and are a formal review of the software design.

- The Functional Configration Audit (FCA) differs from the technical reviews in that it measures the degree of compliance of the actual CI against the Part I developmental specification. It involves reviewing test data to verify performance for each CI. An FCA of the CPCIs is necessary before the CPCI product baseline can be established. Included in the FCA is an analysis by the contractor of the requirements that could not be met, proposed solutions, and a description of the Engineering Change Proposals (ECP) which have been incorporated and tested. The test data are compared to the test plans and procedures to ensure completeness and accuracy. The FCA occurs at the end of the FSD Phase.

- The Physical Configuration Audit (PCA) is the formal examination of the "as built" version of the CIs and CPCIs against the technical documentation to establish the product baseline. It includes a detailed audit of engineering drawings, specifications, technical data and tests used in the production of hardware CIs and a detailed audit of technical descriptions, flow charts, listings, manuals and handbooks for CPCIs. The PCA usually occurs in the Production Phase.

- The Formal Qualification Review (FQR) is the final major review of the hardware CIs and the software CPCIs to verify that the actual performance of the CI complies with the Part I developmental specification and to identify the test reports and data that document the CPCI qualification tests. The FQR can occur in conjunction with the FCA, or if necessary, be delayed until after PCA. The FQR is the point when the CI is officially entered into the Government inventory.

The scheduling of each of these audits and reviews, and the exact structure and detail of the reviews, is the responsibility of the PM. It is his or her responsibility to assure that the program activities are producing a specification and baseline that responds to and delineates the requirements. Clearly, it is possible, but very dangerous, to wait for the Preliminary Design Review to strenuously evaluate the system requirements. By that time, design efforts and program resources will have been expended in two phases, possibly inefficiently. The lesson shown in Exhibit 4-3 of the life cycle cost commitment and expenditure profile points out the potential danger of committing system resources in a period when the requirements may not be well defined.

System requirements drive all of the other areas which relate to the materiel readiness:

- Hardware Design,
- Software Design,
- Test and Evaluation, and
- Integrated Logistic Support.

The emphasis on front-end analysis of supportability issues, as evidenced by the Acquisition Improvement Program (AIP) reinforces the need for:

- early definition of requirements;
- continuous review of requirements throughout the acquisition;
- detailed descriptions of requirements developed by the Air Force PO functional areas (Systems Engineering, Configuration Management, Software Design, Test and Evaluation, ILS, etc.) in concert with the contractors;

- effective measures for:
  - monitoring progress,
  - identifying areas of uncertainty,
  - clearly defining disconnections in relating system specifications development to system requirements,
  - communicating updated information to all of the functional areas; and
- integration of all of the functional system requirements for the total life cycle of the system.

It is fundamentally dangerous to assume that problems, or holes, in the requirements definition can be fixed later in the program, without a significant expenditure of resources, potential delay in program completion and an associated failure to provide an adequate support system. The later discussion of software development problems painfully applies to most of the other areas in the system acquisition process.

The requirements formulation process has been discussed here as the driving entity behind the detailed activities in the technical functions that we feel most heavily impact materiel readiness. Each of these areas relates to one another as well. For example, the hardware and software designs must be compatible with each other, must be adequate for not only the primary mission system (aircraft, missile, communications, etc.), but also the system support equipment. They must be designed to optimize their supportability characteristics and the design characteristics and requirements must be integrated with the ILS and Test and Evaluation efforts.

Test and Evaluation plans, procedures and results must reflect the system requirements, be planned and applied in each

stage of development, and must be designed to respond to, and test for, the required hardware and software capabilities. The results of the T&E activities must feed into ILS planning and analysis since they impact on the ultimate supportability of the system.

The ILS activities are critical to developing a "materially ready" system. These activities cannot be the "late sister" in the design process, deferred until the major hardware and software decisions are made. Deferral of ILS considerations, particularly of elements such as manpower and personnel, training planning and devices, determination of the maintenance philosophy and design and development of the support equipment, can result in a system without sufficient qualified personnel, which cannot be adequately maintained.

In the discussions of these areas and program planning that follow, the intent is to address activities, and problems associated with completing these activities, that directly relate to the issue of materiel readiness. It is impossible for these discussions to cover all possible variations on activities and the many ramifications and difficulties that can occur. That has not been attempted. Rather, these discussions are intended to raise issues that PMs and their staffs should use as starting points in their consideration of how decisions they make on their program can influence materiel readiness. At the end of this chapter is a list of other sources that examine these issues and would be useful to consult.

HARDWARE AND SOFTWARE DESIGN AND DEVELOPMENT

Today's new systems are highly automated, technologically advanced, and rely a great deal on the symbiotic relationship of hardware and software, such as found in advanced avionics systems, built in test equipment (BITE), automatic test equipment (ATE), and other mission and support systems. This concentration on the use of embedded computer resources (ECR) in new systems means, among other things, that materiel readiness must be thought of as being a product of not only successful hardware and software development efforts, but also the successful development of these systems in a joint effort.

Hardware and software development share many things in common, however, the least common of these is the cost of developing and testing them. Currently, in advance technology systems, the cost of developing the system hardware is approximately equal to the cost of developing the software to operate the system. However, this is changing. Exhibit 4-6 illustrates three views of the trend in the relationship of software and hardware costs in the near future. The rising financial and budgetary emphasis also has a similar trend in the cost of maintaining the software, as shown in Exhibit 4-7. All this means that materiel readiness is, to a large extent, going to increasingly relate to the software side of the system. This does not mean that hardware is not an issue. Rather, the system must be perceived as a whole. As technology and hardware reliability and maintainability receive greater emphasis as readiness drivers, software R&M, and the

Exhibit 4-6a.
SOFTWARE IMPACT

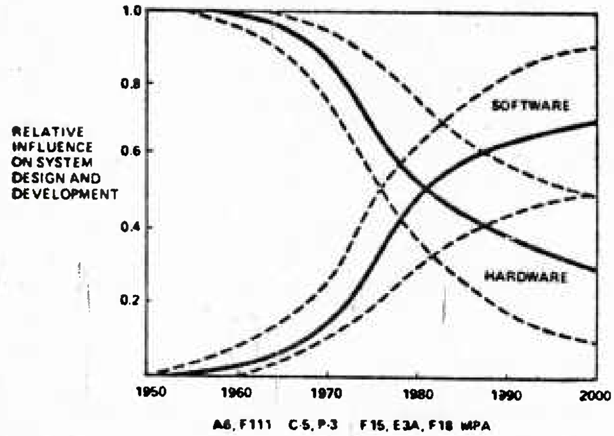


Exhibit 4-6b.
EMBEDDED COMPUTER
HARDWARE vs. SOFTWARE

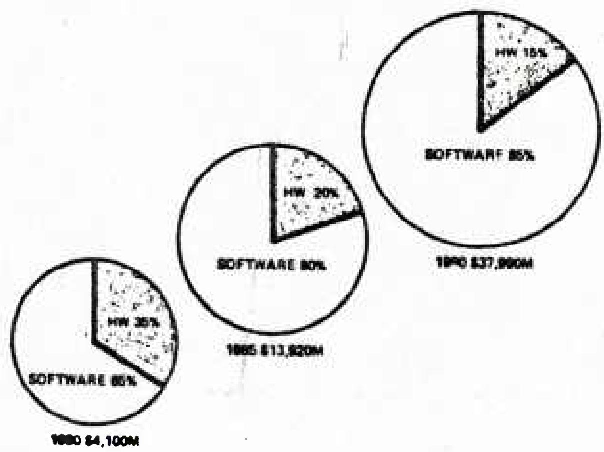
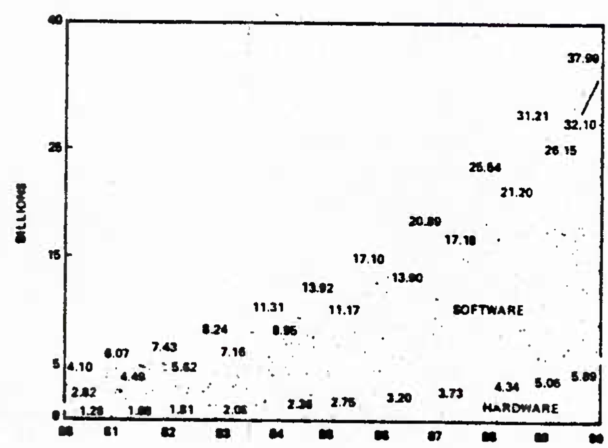
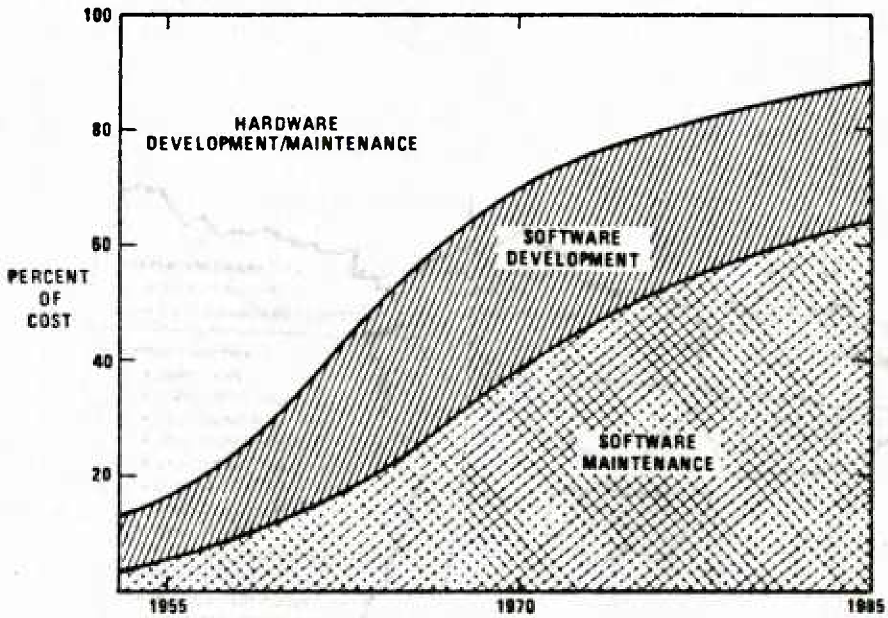


Exhibit 4-6c.
DoD EMBEDDED COMPUTER
MARKET



Source: Grove, H. Mark, "DoD Policy for Acquisition of Embedded Computer Resources," Concepts: Special Issue - Managing Software, Volume 5, Number 4, Defense Systems Management College, Autumn 1982

Exhibit 4-6. TRENDS IN SOFTWARE AND HARDWARE COSTS



Source: Bunyard, Maj Gen Jerry M. and Coward, James M. "Today's Risks in Software Development - Can They be Significantly Reduced?", Concepts: Special Issue - Managing Software, Volume 5, Number 4, Defense Systems Management College, August 1982

Exhibit 4-7. HARDWARE-SOFTWARE DEVELOPMENT AND MAINTENANCE COST TRENDS

interactions and dependencies between the two, must be recognized and managed. Some of the more technologically-oriented relationships among system R&M drivers, support elements, and management structures have be discussed in a recent study by OSD and the Institute for Defense Analyses.[3/]

There are similar threads that run throughout any discussion of materiel readiness and the factors that influence it, regardless of the specific nature of the system. Many of these have been long understood in relation to hardware design. The expansion of system priorities beyond mission-specific priorities to support concerns, and the advances in automation mean that previously learned lessons will be relearned in a new area. One of the main realities to remember is that <u>every piece of the system (hardware and software) that is operated must be maintained</u>. Increasing system readiness means focusing on three major aspects of system capability:

- Reliability - the frequency with which the system fails;
- Maintainability - the ease with which the system can be repaired; and
- Supportability - the extent of the resources required to keep the system operational.

Software, like hardware, must be considered not only from the perspective of the system mission (operations and applications programs) but also the extensive support software which must be developed. Exhibit 4-8 illustrates the iceberg relationship of system and support software. All of this software is

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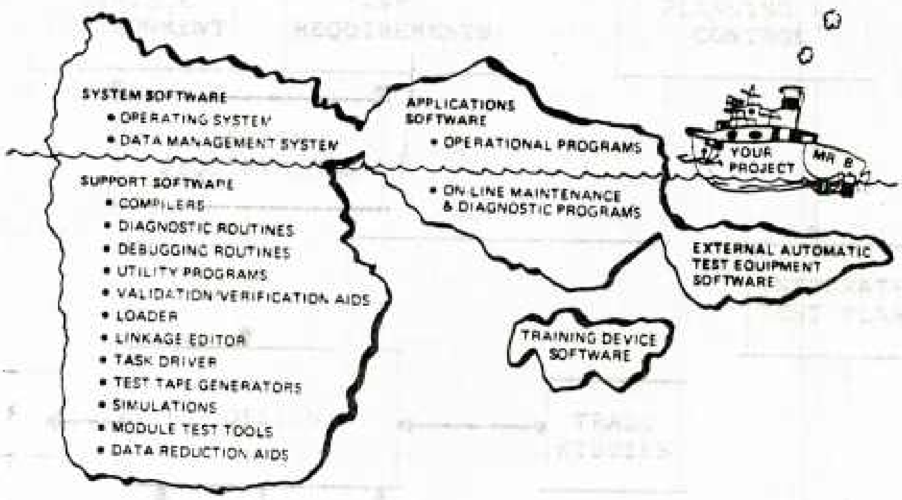
3/ <u>IDA/OSD Reliability and Maintainability Study</u>, Institute for Defense Analyses, November 1983.



Source: McIlvaine, Paul J., "Software Logistics: A Sleeping Giant", Concepts: Special Issue - Managing Software, Volume 5, Number 4, Defense Systems Management College, Autumn 1982

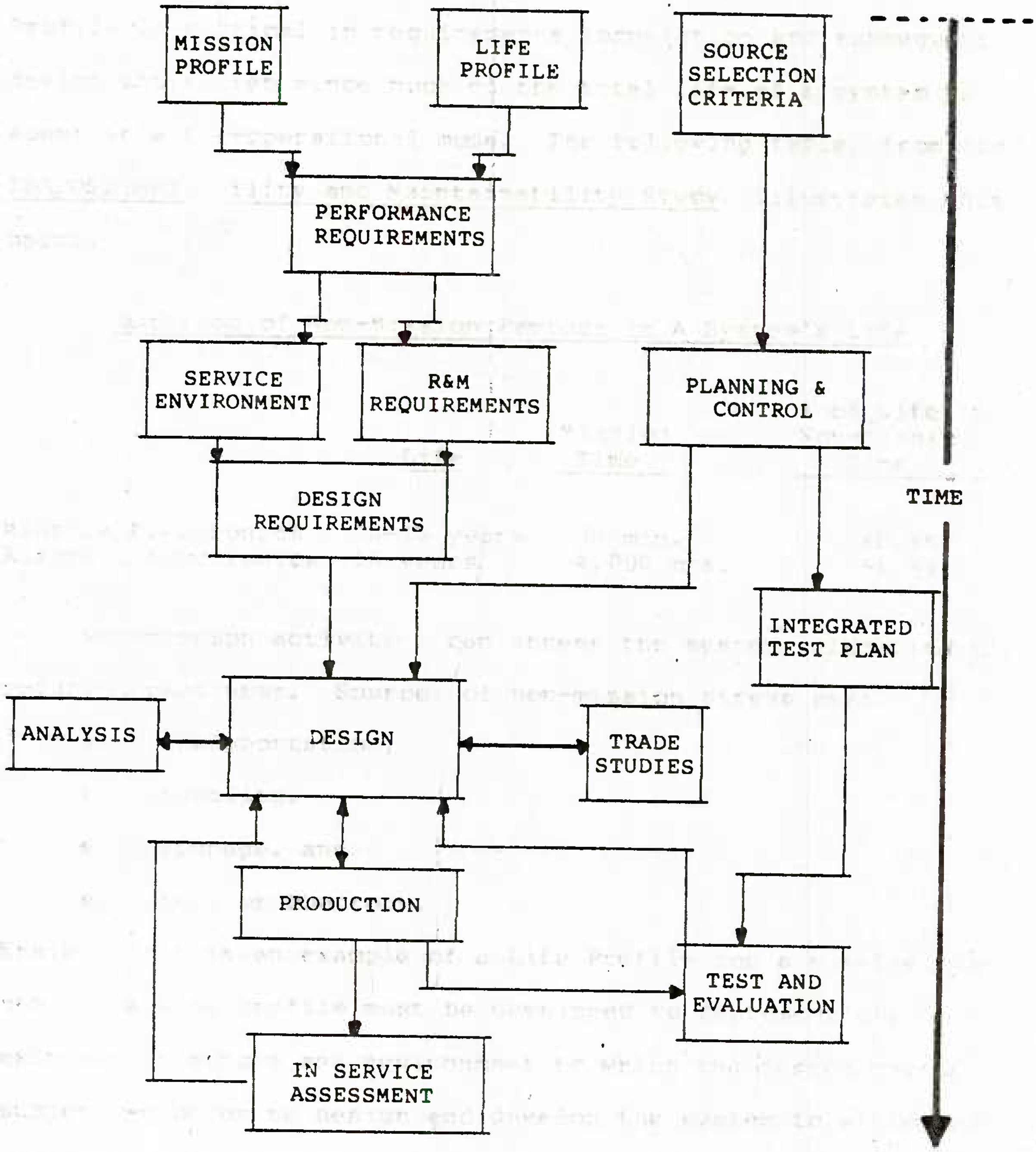
Exhibit 4-8. TYPES OF SOFTWARE

interacting with hardware and the total system must be designed for readiness. This need to consider operational and support requirements of both the hardware and software means that the design and development efforts must keep the total life cycle cost of the system in perspective.

As mentioned earlier, hardware and software design and development share many similar characteristics relating to materiel readiness. The first is the need to have effective, consistent, rigorously validated requirements, specifications, and baselines; early, continuous, thorough reviews of requirements and design; and an effective and comprehensive fault identification and corrective action process in the design and development process. A key step in achieving these objectives is establishment of Mission and Life Profiles as soon as possible after program initiation. The influence of these profiles is shown in Exhibit 4-9.

A mission profile lays out in detail the sequence of activities and set of capabilities the system must be able to perform and withstand during a given mission. If a system has more than one mission, a Mission Profile must be developed for each mission. These profiles are major inputs to the requirements formulation process and must be regularly reviewed and updated based on changes in the intended mission of the system. A mission profile for an air launched missile would take into consideration such factors as those found in Exhibit 4-10.

A Life Profile expands on the Mission Profile by incorporating a time-phased description of the events and environments



Source: IDA/OSD Reliability and Maintainability Study, Institute for Defense Analyses, November 1983

Exhibit 4-9. MAJOR PROGRAM ELEMENT INTERRELATIONSHIPS AND DEPENDENCIES

1. Proposed logistics cycle

2. Means of transportation (truck, railroad, dolley, etc.) of the weapon from one location to the next

3. Range of time spent at each location and the environment encountered there

4. Identity of carrying vehicle (ship or aircraft) on which the weapon will be stored or carried, or from which it will be launched

5. Anticipated locations, in or on the carrying or launching vehicle, where the weapon will be carried or launched from, and the mix of stores carried by that vehicle

6. Anticipated combat tactics employed by the carrying or launching vehicle and its maneuvering characteristics and limitations (speed, altitude, depth, etc.)

7. Anticipated mission profile of carrying or launching vehicle

8. Anticipated operational deployment areas of the carrying or launching vehicle (sea, land, desert, arctic, worldwide, etc.)

9. Required life span of the candidate weapon components (storage life, service life, number of flights, etc.)

10. Operational experience of existing similar weapons

SOURCE: Navy Program Manager's Guide, NAVMAT P-9494, Naval Material Command, July 1983.

Exhibit 4-10. EXAMPLE OF MISSION PROFILE CONTENTS FOR AN AIR LAUNCHED MISSILE

that an item will experience from cradle to grave. The Life Profile is critical in requirements formulation and subsequent design activities since much of the total life of a system is spent in a non-operational mode. The following table, from the IDA/OSD Reliability and Maintainability Study, illustrates this point.

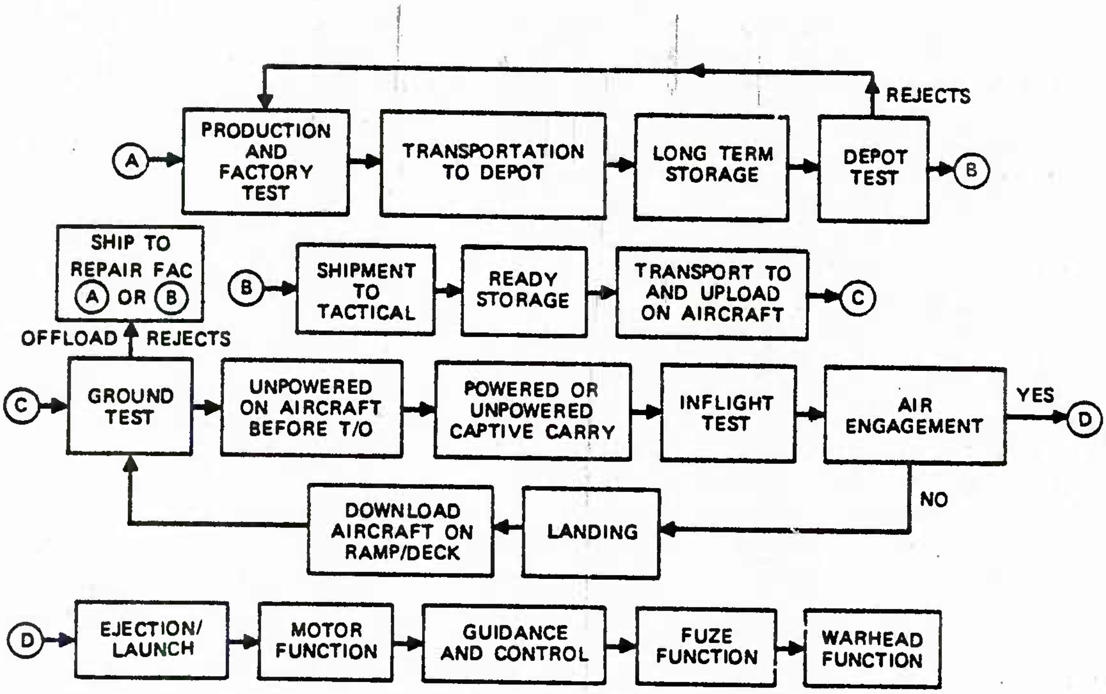
Duration of Non-Mission Periods in A System's Life

	Life	Mission Time	% of Life in Non-Mission Time
Missile Electronics	10-15 years	30 min.	99.9%
Aircraft Electronics	15 years	4,000 hrs.	96.9%

Non-mission activities can stress the system, significantly reducing readiness. Sources of non-mission stress are:

- transportation,
- handling,
- storage, and
- test or checkout.

Exhibit 4-11 is an example of a Life Profile for a missile system. The Life Profile must be developed to represent the extremes in stress and environmnet to which the system may be subject in order to design and develop the system to withstand extremes in temperature, shock, vibration and humidity. These profiles must be developed in conjunction with life cycle cost and design to cost goals in a realistic manner in order to permit



Source: <u>Navy Program Manager's Guide</u>, NAVMAT P-9494, Naval Material Command, July 1983

Exhibit 4-11. SYSTEM LIFE PROFILE

development of realistic and achievable contractual statements of work, as well as functional area plans.

Another major readiness-related consideration in software as well as hardware design is the emphasis on early efforts in design. The increase in the duration of the acquisition of software paces that of hardware. The two cannot be developed independently. Many software designers increasingly state that software design must be given the same early and consistent attention as hardware, in a disciplined software development effort. The following quote amplifies this theme.

"Emphasis continued to be given to cost for development, with little attention being given to the overall life-cycle cost. This leads to a further rise in maintenance costs due to latent errors in the software and inflexible software design, as well as insufficient documentation and support software for maintenance. Support packages, e.g., simulations and test tools, are often treated as throwaways rather than major deliverable items that facilitate both development and maintenance. More emphasis must be placed on the required discipline and rigor early in development to ensure quality, including maintainability of the software throughout the system life cycle.

"...What are the primary problem areas today that lead to schedule slippages, cost overruns, or a software product that falls short of its desired goals? Some of these problem areas are original requirements that are incomplete and/or validated; software design that is not traceable to the requirements and diverges during development; software code that is not maintainable due to poor enforcement of standards; documentation of the system that does not reflect as-built code; software that is insufficiently tested; and timing and storage budgets that are exceeded." 4/

Exhibit 4-12 shows the average duration (in months) of the acquisition of avionics systems.

4/ Bunyard, Maj Gen Jerry M. and Coward, James M., "Today's Risks in Software Development - Can They Be Significantly Reduced?", Concepts: Special Issue - Managing Software, Volume 5, Number 4, Defense Systems Management College, Autumn 1982.

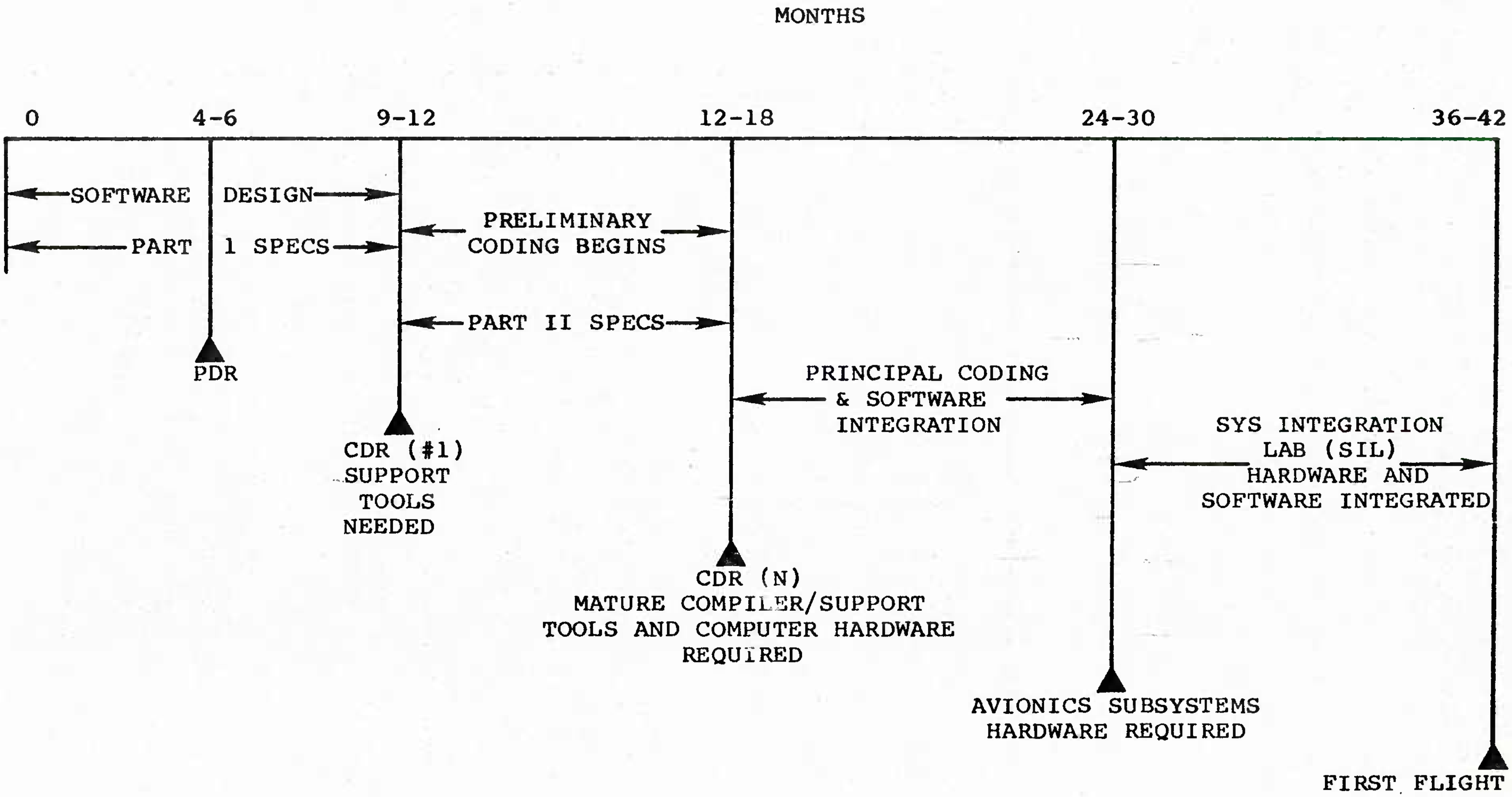


Exhibit 4-12. AVIONICS SOFTWARE DEVELOPMENT SCHEDULE

As with hardware design and development, errors not caught in the early concept development and design effort become embedded in the software only to have much greater cost, operational and maintenance impacts later on. This upward trend in the cost and design impacts of error detection and correction late in the development process is shown in Exhibit 4-13, which shows three trends in the impact of error detection in the software life cycle.

Focusing on early detection of errors means shifting emphasis to the specification development portion of the software development, just as with the development of hardware. Exhibit 4-14 shows this process in terms of activities relating to error introduction and correction and how system verification and validation can be brought to bear to improve this process. The following quote summarizes the managerial orientation the Program Manager should have in managing software.

"There also can be a nightmare of system performance failure, cost overrun, schedule slippage, and even loss of program control awaiting the program manager who does not manage software development with the skill and to the same extent that he manages hardware development. Equal emphasis on software and hardware should apply from the beginning. The ECR must be evaluated as to its supportability: common high order language, availability of compilers, transportability of coding, documentation deliverables, etc. Universal test equipment availability for the hardware and for the software are features which should also be evaluated. In short, system software should be treated as a vitally important configuration item just as much as is the engine in an aircraft weapon system selected for development....

"Software management has been recognized by successful program managers as requiring early, intensive, continuing management. There is no program phase that is too early for concern with software. In fact if the software standards to be utilized are not identified as early as issuance of the system solicitation, some form of disaster is highly probable. Hardware development that is allowed to proceed in advance of software

Exhibit 4-13a.
OVERVIEW OF POTENTIAL
LIFE-CYCLE DEFECTS IN
PROGRAMMING

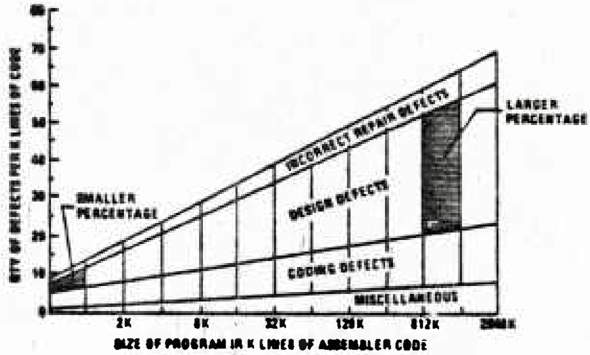


Exhibit 4-13b.
CATCHING SOFTWARE ERRORS
EARLY: PROJECT RESULTS

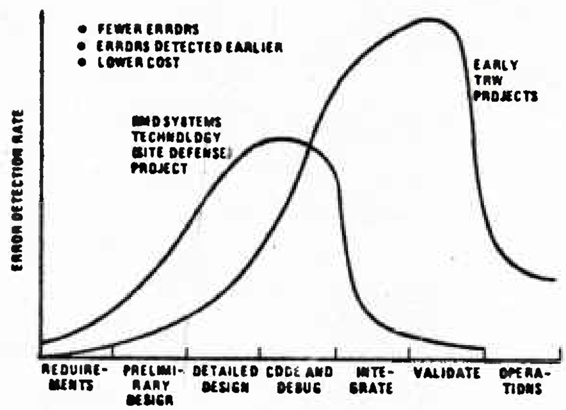
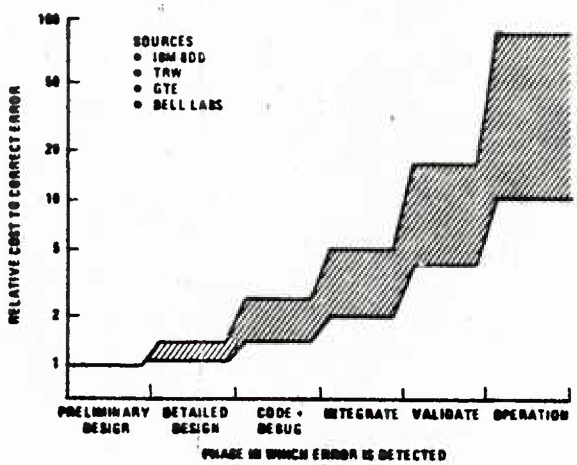


Exhibit 4-13c.
CATCHING SOFTWARE ERRORS
LATE: THE COST



Source: Bunyard, Maj Gen Jerry M. and Coward, James M., "Today's Risks in Software Development - Can They Be Significantly Reduced?", Concepts: Special Issue - Managing Software, Volume 5, Number 4, Defense Systems Management College, Autumn 1982

Exhibit 4-13. LIFE CYCLE IMPACTS OF SOFTWARE ERROR DETECTION AND CORRECTION

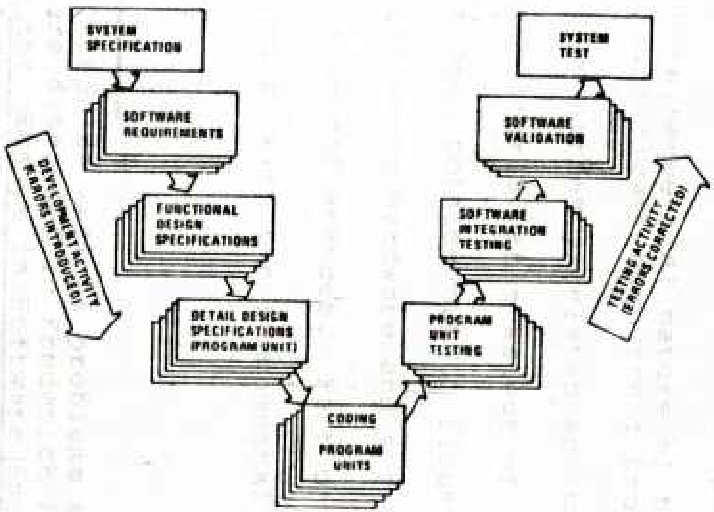


Exhibit 4-14a. SOFTWARE DEVELOPMENT CYCLE

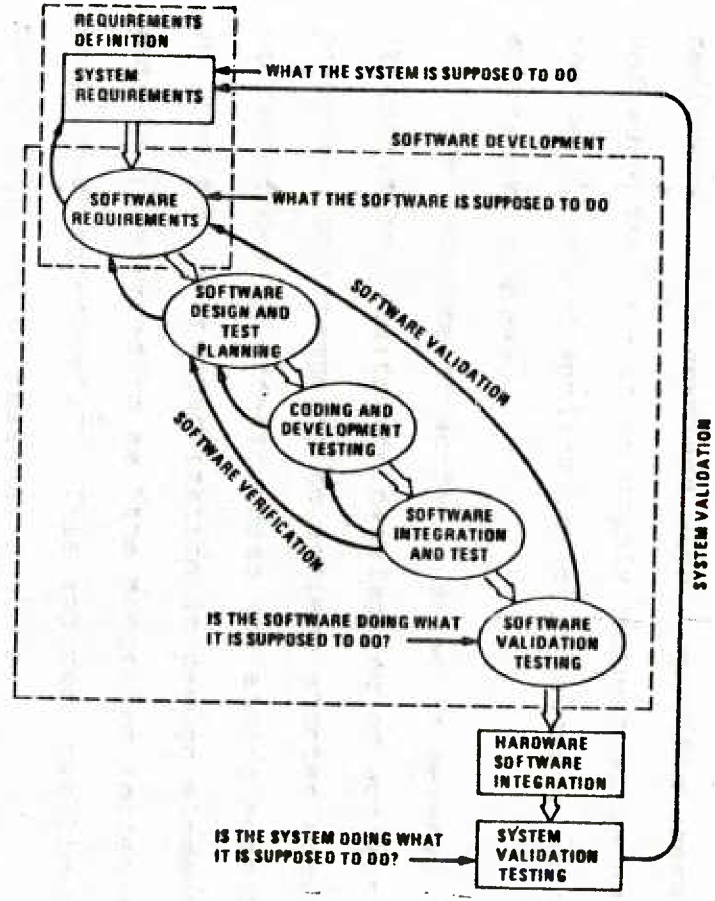


Exhibit 4-14b. SOFTWARE VERIFICATION AND VALIDATION

Source: Bunyard, Maj Gen Jerry M. and Coward, James M., "Today's Risks in Software Development - Can They Be Significantly Reduced?", Concepts: Special Issue - Managing Software, Volume 5, Number 4, Defense Systems Management College, Autumn 1982

Exhibit 4-14. SOFTWARE DEVELOPMENT, VERIFICATION AND VALIDATION ACTIVITIES

decisions will generally constrain system design. Program decisions in good designs are made with engineering balance between hardware and software considerations.

"Program managers are enjoined in DOD-STD-1679A to: (1) make extraordinary efforts in the development phase to ensure maximum reliability and maintainability of software; (2) ensure software is designed to facilitiate efficient changes (even at the expense of technical design efficiency, if necessary); and (3) design software which is strongly influenced by factors which will reduce life-cycle cost, particularly those standards relating to design, languages, intersystem and intrasystem interfaces.

"These guidelines emphasize that software should be designed to make changes easy--and that it is worth extra time, effort, and resource expenditure during the development phase to make the software reliable, maintainable, and less costly over its operational life span. These guidelines, if followed, can help to avoid major problems in system operation....If software is allowed to become complicated and overly refined, a simple change in one or two parameters can demand that major software segments be replaced. Careful design (including memory medium) with regard for probable programming change requirements can simplify the software change problem throughout the system's service life. Costs of updating and maintaining software during the system's service life can be controlled only if the program manager forces the design in a reliable, maintainable direction.

"....There are no golden rules which, if followed, will avoid software problems in the development of a software intensive system. Treating software development as an effort equally important to and concurrent with hardware development has produced the best results. Paying too little attention to, or neglect of software has produced system failures. As in all aspects of program management, in software development as in total system development, there is no substitute for understanding what must be done and doing it at the proper time in the acquisition process."5/

A critical factor influencing the PM's ability to develop effective, error-free, easily maintained software is common throughout system design, operation, and maintenance: the dwindling supply of adequately trained and experienced software programmers and designers. The explosion of computer applications in industry competes for the pool of experienced software

5/ Navy Program Manager's Guide, NAVMAT P-9494, Naval Material Command, July 1983.

designers. This combines with a specific characteristic of software design - it is highly sequential in nature, and allows for only limited application of concurrency or other time-shortening devices.

The sequence of activity shown in several of the preceeding illustrations limits the overlapping of activities. Two approaches for attempting to achieve shorter acquisition times and increased design effectiveness are adding more people to tasks and maximizing standardization in design elements. The former is sometimes referred to as "the Mongolian Hordes versus Super Programmer Approach".[6/] This approach has limited effectiveness due to a number of reasons:

- the difficulty in acquiring and retaining skilled programmers/designers;
- the manloading limits on tasks, largely driven by how much the task can be compartmentalized; and
- the sequential nature of the process does not allow for significant concurrent progression.

While concurrency-related activities are discussed in more detail in Chapter 5, this aspect of concurrency and software design has been pointed out to illustrate that while there are similarities among hardware and software design and development, there are also differences. Part of the reason for these differences has to do with the fundamental nature of hardware and software.

6/ This concept as well as problems associated with software scheduling are discussed in Frederick P. Brooks, Jr.'s, The Mythical Man-Month: Essays in Software Engineering, referenced at the end of this chapter.

It is very difficult to measure progress in software design, and it is not practical to use the same techniques to measure progress as used in hardware. Just as reliability and maintainability goals must be tailored to the specific type of system, so also measures of progress must be developed for software, as they have been for hardware. Among other things, this means a shift in perspective regarding software design from thinking of it as an art, with each program an example of individual craftsmanship - to a disciplined body of knowledge with standards, consistent architecture, language, and design and documentation practices. This emphasis on discipline and consistency will increase the ultimate maintainability and reliability of the software and, therefore, the total system.

The use of standards relates to the second approach for increasing the effectiveness of design approaches: the use of modular designs. This approach is a common interest in both software and hardware. Much effort has been spent in recent years in exploring and encouraging the use of common components, design modules, standardized design elements and the application of standards to both hardware and software design. The intention is to increase system readiness and decrease acquisition time and cost. The trade-off is between performance flexibility and inter-system commonality, increased maintainability, and design reliability. From a hardware perspective there has been a very slow building of enthusiasm for this idea. In software development there has been a significant move toward revising the

relevant military standards to standardize the high order languages (e.g., DoD-wide use of ADA), system architecture, and the design and development of reusable code modules. Continued exploration of all of these will increase the capability of designers and managers to design reliability and maintainability into the system. These are just a few of the major elements in hardware and software design impacting materiel readiness. The reader should continue to explore these areas, and should review the references at the end of the chapter. The following discussion focuses on test and evaluation activities related to materiel readiness.

TEST AND EVALUATION

A major factor in a system's readiness when fielded is the effectiveness of the Test and Evaluation (T&E) program applied in the acquisition. T&E plays a pivotal role in that it:

- evaluates the design in terms of how it satisfies the system requirements,
- supports determination of the success of the development efforts,
- supports determination of the system's operational capability,
- supports the system qualification process, and
- provides actual information on system operational and maintenance capabilities to feed into ILS planning.

A difficulty intrinsic in the effective use of testing and evaluation in the system design is the fact that there must be something to test in order to obtain results. Test results then

become a significant decision driver, particularly in transitioning from FSD to Production. The revision of the DSARC decision process making the FSD decision the initial commitment to producing the system means that all data available to support this decision is critical. Historically the lack of sufficient and comprehensive T&E data to support final baseline determination decisions has forced the production of systems needing additional design corrections.

The Test and Evaluation process is usually composed of four major planning and testing phases occurring in each acquisition phase. The first activity is the development of the Test and Evaluation Master Plan (TEMP), developed in the Concept Exploration Phase. This phase's activities also include initial feasibility testing in which test experience from other, related or similar systems is evaluated as a source of potentially useful insights in developing the test plans. The T&E activities must be designed to address mission-critical components, stress extremes in both the mission-related and non-mission-related system life activities, and the reliability and maintainability of the system. The latter is particularly important since R&M is now being incorporated as a contractual design <u>requirement</u> versus <u>goal</u>. This shift in the specification of R&M thresholds means that T&E activities must be designed to test for the system's designed R&M parameters. This also means that T&E planning must be integrated with any off-line R&M technology maturation programs that apply to the program.

The Concept Exploration Phase feasibility studies focus on both parts of the system: the operational system and the support system. T&E activities relating to the operational system concern:

- mission and non-mission stresses,
- environmental testing, and
- system reliability (fault isolation and correction).

Support system T&E efforts must be significantly more extensive. This is due to the interrelationships between the developmental T&E activities and the development of the support test capability in the fielded system (i.e., the diagnostics, ATE, BIT, etc.). The interaction of test results in the development of not only the system diagnostics but the overall support system is critical. As discussed in the previous section on hardware and software design and development, the critical shortage of qualified manpower available to operate and maintain the system, in conjunction with highly automated operational systems, has produced a greater emphasis on the use of ATE, BIT and recently the introduction of the MATE concept (modular automated test equipment). Particular aspects of the diagnostic system are discussed later in this chapter.

Although testing activities begin in the CE Phase, they are concentrated in the later phases. The actual T&E activities follow these Concept Exploration Phase activities. There are two categories of testing for most systems:

- Developmental Test and Evaluation (DT&E) is conducted in the Demonstration and Validation Phase (DT&E-I) and in the Full-Scale Development Phase (DT&E-II). These tests are conducted by the AFSC program office Test and Evaluation Directorate, and the contractor(s), with the support of the Operational Test and Evaluation (OT&E) team, for major systems, usually the Air Force Operational Test and Evaluation Center (AFOTEC). The major objectives of DT&E are to:

  - assess system specification compliance, deficiencies, compatibility, OT&E readiness, configuration changes;
  - assess program risks/trade-offs;
  - assess logistics supportability/survivability;
  - verify technical order completeness;
  - gather training program and environmental impact data; and
  - determine system performance limitations.

- Operational Test and Evaluation (OT&E) is also divided into two parts: Initial OT&E (IOT&E) and Follow-on OT&E (FOT&E). IOT&E is conducted throughout the first three acquisition phases, up to the final production decision. FOT&E is performed during the Production Phase. IOT&E is usually performed on prototypes of the system to test subsystem interactions and performance, and to test the overall system's operational effectiveness. FOT&E, initiated after production begins and sometimes continuing throughout the system's life cycle, can be divided into two phases: FOT&E(I) intended to refine operational suitability and effectiveness estimates and to evaluate corrective actions resulting from IOT&E. FOT&E(II) measures the system's ability to meet changing operational requirements, refines operational tactics and programs, and identifies and confirms correction of system deficiencies. The major objectives of OT&E are to:

  - estimate operational effectiveness/suitability;
  - identify operational deficiences;
  - recommend/evaluate configuration changes;
  - provide logistics support, training, tactics, operation and support cost data;

- determine technical data/support equipment adequacy; and
- estimate system survivability.

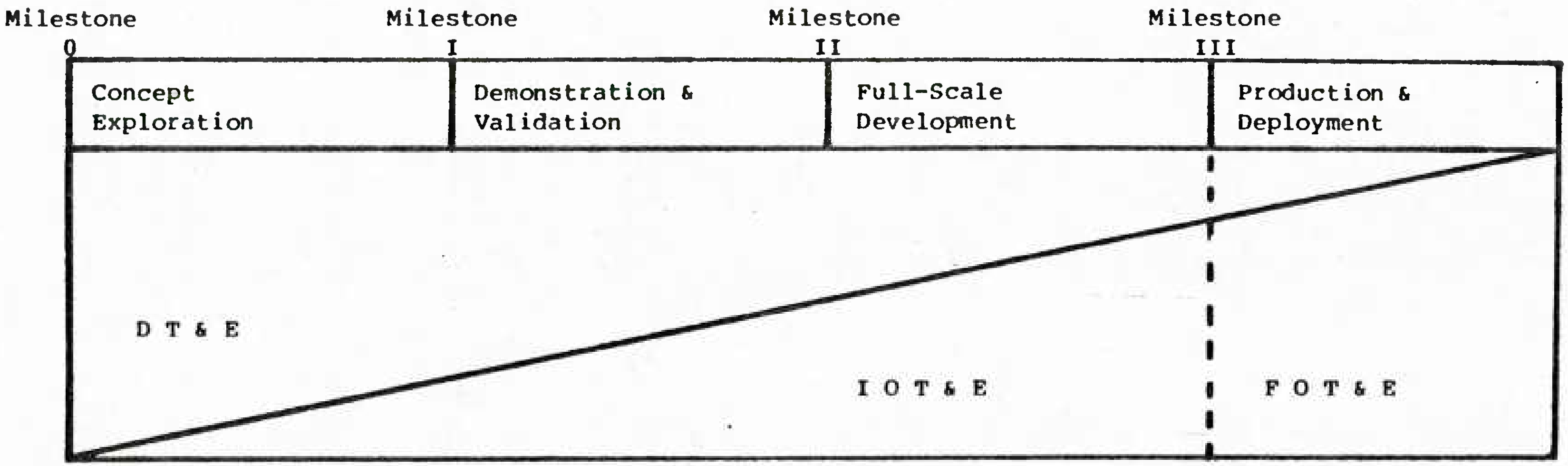
Exhibit 4-15 illustrates the basic relationship of DT&E and OT&E in systems acquisition. In order to maximize the effectiveness of these testing and evaluation efforts, planners are encouraged to conduct them with a view towards interchanging test results. Program experience has shown that overlapping DT&E and OT&E can be beneficial to accomplishing the program objectives, however, there are inherent risks which must be recognized. These are discussed in Chapter 5.

Software also is subject to a T&E process similar to hardware. As addressed in the previous discussion, problems found late in a software development effort tend to have a more profound effect on overall accomplishment of the program goals than problems identified and corrected earlier. Software designers have tended to argue that the critical function in having an adequate and effective test program is early planning and development of a comprehensive:

- test plan,
- test procedure, and
- test report.

The following suggested approach has been developed and applied successfully in a variety of aerospace software development efforts.[7/]

[7/] This is a variation on the basic Test Plan format specified in DoD Standard 7935, <u>Automated Data Systems Documentation Standards</u>. It has been extracted from the unpublished paper: Insley, Robert R., "General Form for a Verification Test Plan and Procedure," San Pedro, CA. (undated).



- Assist alternate concept selection

- Minimize design risks
- Demonstrate technical/operational feasibility
- Prototype testing

- Demonstrate engineering design complete
- Demonstrated contractual compliance
- Identify/correct deficiencies
- Estimate operational suitability/effectiveness

- Evaluate system improvements, corrections, modifications
- Refine estimates of operational effectiveness/suitability
- Evaluate system under changing environments

Source: Weapon Systems Acquisition Guide

Exhibit 4-15. TEST AND EVALUATION CYCLE

GENERAL FORM FOR A VERIFICATION
TEST PLAN AND PROCEDURE

The following is a cook book procedure for writing a software verification plan and procedure. It is intended that the document will be written in three parts. The plan should be written first and submitted for review and approval, then the procedure should be written. After the precedure has been run and the results reviewed the test report should be written. This approach is being suggested to achieve the following conditions:

- test repeatability,
- control of test environment,
- requirements traceability, and
- test conclusiveness.

A. TEST PLAN

- PREFACE - State the software involved. This may be a module within a system, a partially integrated system, or a total system. Reference the system's identification and identify the hardware on which the test will be run.

- 1.0. PURPOSE - State the purpose of the test (e.g., verify the software requirements as they pertain to a specific module, etc.). If the requirements are a subset of a total system, define the subset (e.g., display requirements, etc.).

- 1.1. GENERAL DESCRIPTION - Describe how the test is to be run (e.g., as a stand alone test using test drivers and simulated data, or as a complete system with live data, etc.).

- 1.2. REFERENCES - List all reference documents by ID, name and revision (e.g., Government standards, company standards, system requirements, etc.). It is assumed that a Software Test Control standard is in place and will be referenced.

- 1.3. TEST ENVIRONMENT - Give a general description of the hardware and software to be used showing overview diagrams.

- 1.4. TEST OBJECTIVES - This section should reference a set of appendicies, consisting of the following information:

  - APPENDIX A - Contains an abstract of requirements that pertain to this test.

  - APPENDIX B - Contains the test objectives which were derived from the requirements in Appendix A.

B. <u>TEST PROCEDURE</u>

- 2.0. TEST PROCEDURE - It is intended that after approval of the plan, the procedural portion will be created and added to the document.

- 2.1. TEST DESCRIPTION - Define the makeup of the test in terms of how many phases there will be and what each phase will test. Also explain whether the test will be run by an operator from a terminal or automatically run via command files under the control of the operating system. If there are unique characteristics about the test which are important, explain them (e.g., the test will be run using partially completed system hardware).

- 2.2. VERIFICATION CROSS REFERENCE - This section should reference an appendix (Appendix C) which will contain a set of matricies defining which objectives will be tested in what phases and in what test steps.

- 2.3. HARDWARE ENVIRONMENT - Describe the hardware to be used noting equipment nomenclature. Also provide detailed interface hookup diagrams.

- 2.4. SOFTWARE ENVIRONMENT - Describe the support software to be used (e.g., operation system, simulation program, etc.). Also give software ID and revision data. In addition, the target software should be described. If there are any test data files or command files involved they should be defined here.

- 2.5. SCENARIO - This section should contain an actual step-by-step procedure which will explain just how each previously defined test objective is to be tested. A basic format will be described here which uses the test step approach. There are other formats which can also be used. The format will be defined using an indentured paragraph numbering approach.

- 1.0. - TEST NAME

- 1.X. - PHASE NAME - (where X is 1 to the total number of phases). Any special test conditions for the phase should be described here.

- 1.X.Y. - TEST STEP NAME AND OBJECTIVE(S) - (where Y is 1 to the total number of steps). The test objective(s) may be referenced by objective number to Appendix B.

- 1.X.Y.1. - REQUIRED INPUTS - Define the inputs in terms of data flags to be set, etc. These inputs must be defined in terms of their official names (e.g., the associated mnemonic as it appears in the code).

- 1.X.Y.2. - EXPECTED RESULTS - Explicitly define the expected results in terms of values and locations, displayed conditions, etc.

- 1.X.Y.3. - INITIATING CONDITION - Give the precise command(s) to cause the step execution. If the procedure is in a command file the command(s) should be executable by that command file. If the command or command sequence is to be executed manually, then the exact sequence must be defined. This is important for test repeatability.

- 1.X.Y.4. - OBTAIN RESULTS - Give the precise command(s) to retrieve the results. If a command file is being used, then the specific executable command(s) should be defined which will display the contents of specific memory locations, dumps, etc. If the results are to be retrieved manually, then instructions should be given as to how to achieve them.

- 2.0. - POST TEST ANALYSIS

- 2.X. - There should be a tabulation of results for each test phase (X). This tabulation should state whether each step has passed or failed. If a step has failed the conditions of failure must be stated. It is assumed that these results will be submitted to a Test Review Authority for statusing.

C. <u>TEST REPORT</u>

- 3.0. TEST REPORT - This is the third part of the document to be created. It is assumed that it will be written after the Test Review Authority has stated its findings. The contents of the report should include at least the following:

- the names of test participants and observers,
- a brief description of the test activity,
- the outstanding results (i.e., failures),
- the findings of the Test Review Authority,
- the justification of any waivers or disclaimers, and
- the actual copy of the plan/procedure, test results and post-test analysis.

The intention of this part of this chapter has been to consider <u>some</u> of the readiness-related aspects of hardware and software Test and Evaluation. Clearly, there are many other aspects of T&E which can impact system readiness. The reader is directed to consult the references following this chapter for more detailed discussions on T&E as a readiness driver.

INTEGRATED LOGISTIC SUPPORT

No discussion of materiel readiness would be complete without a discussion of Integrated Logistic Support (ILS). ILS and the related Logistic Support Analysis (LSA) relate to a set of activities concerned with the analysis of requirements and development of a capability to maintain the system once fielded. DoDD 5000.39 gives these definitions of ILS and LSA:

- <u>Integrated Logistic Support</u>. A disciplined, unified, and iterative approach to the management and technical activities necessary to:

  a. Integrate support considerations into system and equipment design.

  b. Develop support requirements that are related consistently to readiness objectives, to design, and to each other.

c. Acquire the required support.

d. Provide the required support during the operational phase at minimum cost.

- Logistic Support Analysis. The selective application of scientific and engineering efforts undertaken during the acquisition process, as part of the systems engineering process, to assist in:

  a. Causing support consideration to influence design.

  b. Defining support requirements that are related optimally to design and to each other.

  c. Acquiring the required support.

  d. Providing the required support during the operational phase at minimum cost.

That same directive identifies 10 ILS elements and defines them as follows:

a. Maintenance Planning. The process conducted to evolve and establish maintenance concepts and requirements for the lifetime of a materiel system.

b. Manpower and Personnel. The identification and acquisition of military and civilian personnel with the skills and grades required to operate and support a materiel system over its lifetime at peacetime and wartime rates.

c. Supply Support. All management actions, procedures, and techniques used to determine requirements to acquire, catalog, receive, store, transfer, issue, and dispose of secondary items. This includes provisioning for initial support as well as replenishment supply support.

d. Support Equipment. All equipment (mobile or fixed) required to support the operation and maintenance of a materiel system. This includes associated multiuse end items, ground-handling and maintenance equipment, tools, metrology and calibration equipment, test equipment, and automatic test equipment. It includes the acquisition of logistics support for the support and test equipment itself.

e. <u>Technical Data</u>. Recorded information regardless of form or character (such as manuals and drawings) of a scientific or technical nature. Computer programs and related software are not technical data; documentation of computer programs and related software are. Also excluded are financial data or other information related to contract administration.

f. <u>Training and Training Support</u>. The processes, procedures, techniques, training devices, and equipment used to train civilian and active duty and reserve military personnel to operate and support a materiel system. This includes individual and crew training; new equipment training; initial, formal, and on-the-job training; and logistic support planning for training equipment and training device acquisitions and installations.

g. <u>Computer Resources Support</u>. The facilities, hardware, software, documentation, manpower, and personnel needed to operate and support embedded computer systems.

h. <u>Facilities</u>. The permanent or semipermanent real property assest required to support the materiel system, including conducting studies to define types of facilities or facility improvements, locations, space needs, environmental requirements, and equipment.

i. <u>Packaging, Handling, Storage, and Transportation</u>. The resources, processes, procedures, design consideratinos, and methods to ensure that all system, equipment, and support items are preserved, packaged, handled, and transported properly, including environmental considerations, equipment preservation requirements for short- and long-term storage, and transportability.

j. <u>Design Interface</u>. The relationship of logistics-related design parameters, such as R&M, to readiness and support resource requirements. These logistics-related design parameters are expressed in operational terms rather than as inherent values and specifically relate to system readiness objectives and support costs of the materiel system.

The variety of elements included under the umbrella of ILS gives an indication of the multifaceted nature of support. Emphasis on readiness <u>must</u> mean emphasis on ILS.

Historically, ILS has been given less concern and a lower priority in systems acquisition. In trade-offs between performance, acquisition costs, schedule constraints, and support, support has had a tendency to come out the loser. Expenditure of near-term funds on immediate problems, primarily in technical design, meant that ILS planning and acquisition has frequently been deferred. The realization that having a mission-capable system means having an in-place support system has been known to the user community and logisticians (or logistically-sensitive designers) for a long time. However, this point has been frequently missed by decision-makers.

One way of looking at ILS is to consider the elements that relate to developing an ILS capability and those which must be in place in order to have an ILS capability. The former could include:

- maintenance planning, and
- design interfaces.

In order to actually <u>have</u> a fielded support capability, such as one sufficient to meet IOC, the remaining elements of logistics support must be in place:

- adequate number of properly trained manpower available upon system fielding;
- supply support (initial and replenishment spares and associated inventory management and control procedures);
- support equipment, including system unique transportation and storge equipment, test equipment (BIT and ATE), ground support equipment, tools (e.g., metrology and calibration equipment), etc.;

- technical data/documentation/orders, including the detailed description of the system configuration, the most recent as well as all versions of the system currently in the field, full documentation of the hardware and software maintenance procedures for the mission and support equipment; and all technical or engineering drawings, manuals or instructions;

- computer resources support, the Embedded Computer Resources (ECR) to operate and support the system, and all of the elements of that capability, to the full breadth of maintenance support (i.e., below depot level);

- facilities, the flight line maintenance, avionic intermediate support facilities, training facilities, etc., and the organization and arrangement of these facilities in a manner promoting efficiency and productivity; and

- development of appropriate containers for the transportation and storage of the system, components and support equipment.

In planning and developing an ILS capability and in conducting the associated LSA, the manager must maintain cognizance of certain primary concerns. First, in order to maximize effectiveness, as with requirements formulation, hardware and software design and development, and test and evaluation, ILS activities must be:

- initiated early (in Concept Exploration);

- actively managed throughout the program;

- managed with a priority toward maintaining oversight of the interrelationships and dependencies among the ILS elements; and

- focused as early as possible on analyzing requirements and associated risks in producing an effective and integrated support capability.

As discussed elsewhere in this handbook, historically, ILS elements have been deferred, postponed, truncated, or eliminated in

systems acquisition. The result has been the fielding of a system without a sufficient support system. This, in many cases, means buying a support capability or parts thereof via interim contractor support. There are pros and cons to this approach in that is allows the system to be fielded without a complete logistics capability residing in the Air Force. It also allows for continued maturation of the R&M and maintenance under the supervision of highly qualified technicians and engineers. On the other hand, this maturation may be somewhat artificial in that, like OT&E, the true system R&M cannot be realistically evaluated because "Ph.D engineers rather than E-3s are performing the analysis." There is also the fact that contractor personnel are not military personnel, and are not part of the deployable infrastructure.

Another fundamental aspect of ILS has been alluded to in this discussion and more generally in the Chapter 2 discussion of problems with managing to readiness: there's a lot that goes into having an integrated support system. The ten elements of ILS are not all of the factors influencing the development of an ILS capability. Significant interactions exist among many groups within the PO or working in cooperation with the PO, as can be seen from the following quote from the <u>System Engineering Management Guide</u>.

"Although Logistics is primarily concerned with the system deployment and operations phase, it is a major cost driver and a vital issue in system readiness, reliability, sustainability, maintenance concept, maintenance level selection, human engineering, safety, testability, repair/replace decisions, special training, standarization, etc. Most of the significant decisions that affect logistic support cost will have been made before the

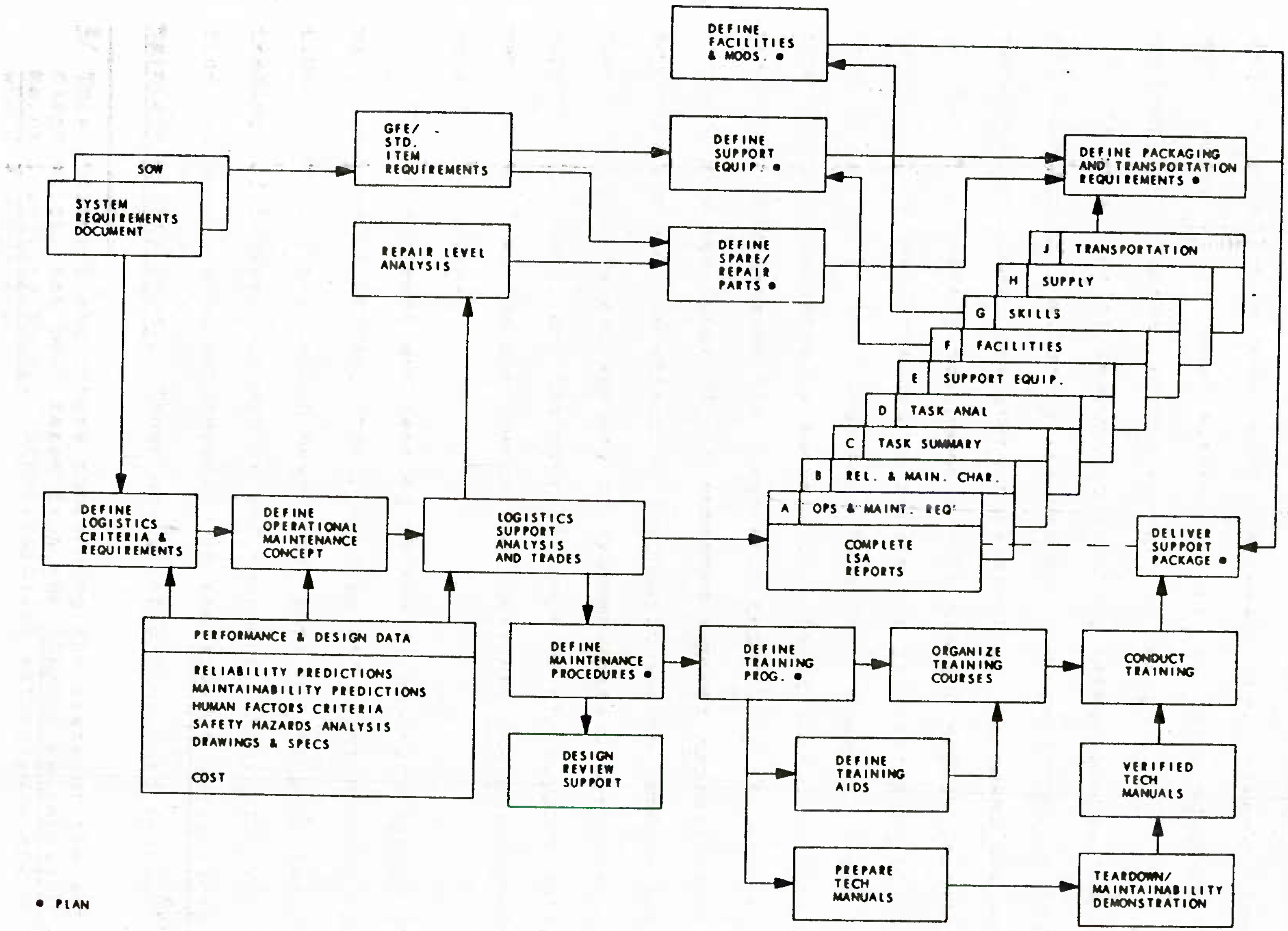
production phase begins. On a typical program, 95 percent of the total program costs will have been committed by the Critical Design Review (CDR) milestone in the FSD phase. Logistics considerations have far reaching effects on inventory, manpower, tools, and equipment."

ILS task activities peak in the FSD Phase. It is in this phase that much of the logistic system is fully designed and developed. Exhibit 4-16 shows the major ILS-related activities and their relationships, in the FSD phase. Much of the planning and initial development activities should be conducted or at least initiated long before this phase, since delaying until FSD significantly limits the impact any of the ILS elements can have on the design. Exhibit 4-17 illustrates how decisions in the maintenance concept influence and interact with the ILS development process.

In considering system readiness and ILS, several of the capability-related ILS elements play particularly critical roles. These elements, in fact, play dual roles in that they contribute to the overall logistics support capability, and they influence one of the major systems that relates to readiness: the diagnostic system. These elements are:

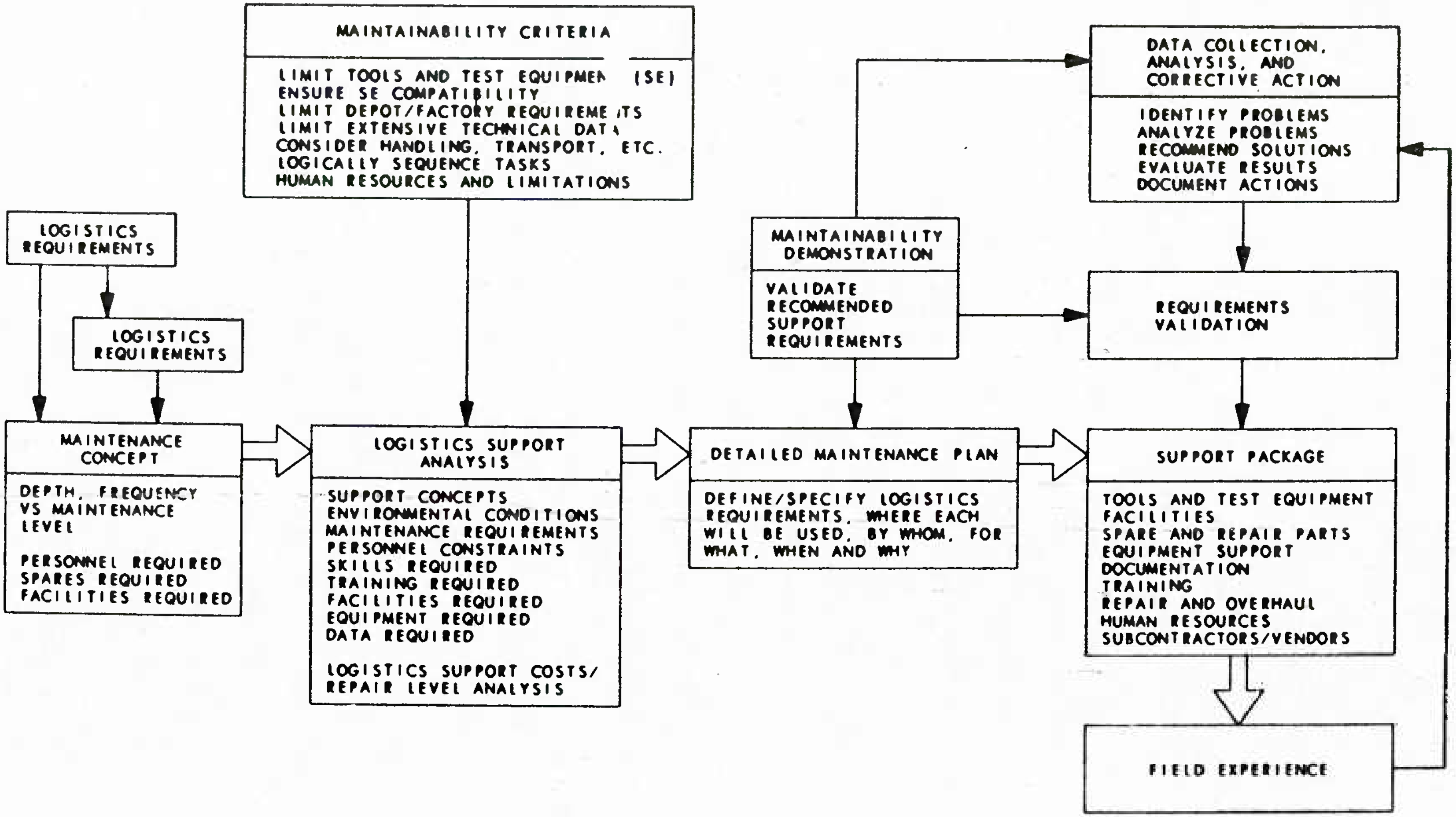
- manpower and personnel,
- training and training support,
- support equipment, and
- computer resources support.

Manpower and personnel, and training and training support, have for a long time been thought of collectively as manpower, personnel and training (MPT). Efforts in the last several years



Source: System Engineering Management Guide, Defense Systems Management College, 30 October 1983.

Exhibit 4-16. INTEGRATED LOGISTIC SUPPORT TASK FLOW DURING FSD



Source: System Engineering Management Guide, Defense Systems Management College, 30 October 1983.

Exhibit 4-17. MAINTENANCE TASK FLOW AND INTEGRATION WITH ILS

have been directed toward recognizing that they must be considered separately, both in terms of developing estimates of requirements and in developing the capability. However, they both relate to the human element in the logistics equation (as opposed to the human factors element in design).

In an effort to respond to shifting demographics, the critical shortage of adequately trained enlisted personnel, with the required aptitudes, designers have steadily increased the use of automated diagnostic equipment - BIT, ATE and MATE. This tradeoff has also been intended to reduce the proliferation of support test equipment in the diagnostic function. However, these trades have not been universally successful. It is useful to consider these problems because the diagnostic capability is becoming increasingly the focus of the embedded support capability of the deployed system. An effective diagnostic system impacts the quantity, quality and variety of systems spares, personnel, support equipment, and the overall scope of the support establishment, as well as the confidence the operators and maintainers have in the system.

The development and testing of the diagnostics system is a major concern of AFOTEC. Their studies and experience in operational test and evaluation have shown some of the problems in trading off between automation and manpower. Many of these findings have also been addressed in the IDA/OSD Reliability and Maintainability Study. These are briefly discussed below.[8/]

8/ This statement and others concerning the state of the art in diagnostics, has been taken from the IDA/OSD Reliability and Maintainability Study. Other, similar extractions are noted where appropriate.

"Diagnostics as an area of engineering design, is an immature discipline when compared to reliability. In diagnostics, there are not accepted definitions of requirements that can be used for contracting that are directly understandable to a designer and that can be related to field experience."

Also, the definition of what constitutes the diagnostic system can vary from system to system.

Current systems for providing field experience data are not sufficient to support diagnostic system design efforts because they do not provide sufficiently detailed information on the system failure-resolution/cannot duplicate actions.

The use of automated systems in diagnostics has tended to limit the inherent understanding of the operations of the system, making it more difficult to maintain the diagnostic equipment, and creating distrust in the information provided by the system.

The more complex the relationship between the end item and the support equipment, the more difficult it is to keep the systems operational/maintained. Hybrid, integrated diagnostic systems, combining automation and manual requirements are even more difficult to analyze because of the unknowns associated with the manual/automated interactions. The manual aspects have much uncertainty and are difficult to quantify. Highly automated systems, however, cannot be readily fixed in the field. The designer must develop the appropriate mix of test equipment availability, reliability and support, personnel availability and training, available technology, and life cycle cost, to develop the most balanced system given the user's requirements and operational needs.

The use of automated or semi-automated diagnostics means that resources must be dedicated very early in the concept development, particularly regading large scale integrated (LSI) circuits or very high speed integrated circuits (VHSIC).

The failure of BIT equipment and ATE to fulfill the facility isolation and detection requirements, to reduce the false alarms/ cannot duplicate failures, has in many cases meant a significant increase in maintenance personnel required for the system, once fielded. The E-3A is a significant example, with a new requirement for an additional 18 radar and 9 support equipment technicians, each of which required six additional months of formal training and 25 months of on-the-job training (OJT), just to develop sufficient proficiency in troubleshooting.

Both AFOTEC and the <u>IDA/OSD Reliability and Maintainability Study</u> identified a significant problem with the way in which diagnostic system parameters (e.g., failure rates, false alarms, faults isoloated, etc.) were expressed in contractual statements of work. Targeted goals can be easily interpreted to provide a bare minimum capability. The following quote from an AFOTEC briefing on weapon systems diagnostics describes what can happen.[9/]

"....We have not done a good job in the way we articulate our needs to contractors,...and, we as testers needed to improve evaluation methods to provide decision makers more meaningful information. [Lets] look at one way specifications have been interpreted in the past.

"I'll use some number values which were an in some cases still are familiar and commonly used to specify automated needs,

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9/ Lohr, Major Douglas, "Weapon Systems Diagnostics," (Briefing), Air Force Operational Test and Evaluation Center, (undated).

and design a 90 percent fault detection and 80 percent isolation system for you. When we, the Air Force, say 90/80 we want 90 percent of the faults discovered which can occur and 80 percent of all faults isolated. I, as a contractor, can interpret this specification [in the following manner]. If I expect 100 faults in 1000 operating hours for my system, of 10 black boxes and I know that, based on failure modes and effects analysis 90 of those 100 faults will occur in 5 of 10 boxes, I will only automate 5. I've fulfilled the 90% FD requirement. I can't be expected to automatically isolate what I don't automatically detect, I'll automate only 4 of 5 boxes to get my 80% isolation capability. You can see the disconnect. What I wind up with is 90% FD and 72% FI going in - the bare minimum. We first noted this type of problem with the E-3."

The following is an approach developed by AFOTEC for developing a more effective diagnostic capability, addressing also the relationship of diagnostics to logistics.

"As early as possible users should develop and articulate their concepts. Next they should determine constraints, keeping the repair process in mind. They should set optimum bounds on downtime and establish what will be available in manning and skills and what support equipment they will want or can live with considering deployment and home base support. Then based on constraints develop requirements and state emphatically the outer limit acceptable in order to do the mission with the money available. And, continually work with developer provisioner and tester to insure what has typically happended doesn't continue: namely, logistics lagging hardware development and operational requirements.

"As developers, first concern should be user requirements once the Air Force need is established, rather than continuing to attempt to achieve 100 percent diagnostics through a contractual specification as a separate effort, AFOTEC recommends a blend of automated and manual diagnostics techniques be developed based on user maintainability parameters, such as maximum downtime or turn-around time. This optimum blend can be achieved through direction of trade studies in the statement of work and insistance on concurrent hardware and diagnostics development. In this way the customer should get a more usable product. Some of the shortfalls of the past can be avoided by working within the limits of current technology. Thorough integrated logistics support planning can mold diagnostics into a whole rather than fragmenting BIT from support elements such as training, technical data and support equipment over long periods of time. Interim contractor support (ICS) is normally available for some specified period for each new system. Part of that ICS could be a requirement to mature diagnostics in the field. [Developers and the

test community] are all too familiar with the number of problems that only show up after a period of use in the operation environment. One of the most successful methods used to fix initial problems found during IOT&E was with the EF-111A. On that system tech data writers, software engineers and representaives from the SPO, TAC and the operational test center worked together to close the loop and plug holes in diagnostics.

"100 percent coverage [is needed], but overlap, particularly in critical fault detection and isolation should be considered. For instance a manual system and additional formal training to confirm the presence of an operator reported system malfunction [which] should [be able to be found] with maintenance BIT, but may not be able to [be found].

"And finally, a good way to mature diagnostics early is to require the contractor to use technical data, BIT and [support equipment] as blue suiters will, and have everyone use existing support during testing.

[AFOTEC also has suggestions regarding the role of the test community.] "The earlier [test groups] get involved, the better. [They] need to build [their] approaches and plans based on user needs, which makes it mandatory that [they] work with users and developers to get the criteria for the systems. [The test community is] now folding diagnostics into the areas where [they] feel it belongs; maintainability as it aids technicians in their troubleshooting efforts; mission reliability and how well BIT informs the operator of the condition of a system, particularly, regarding critical faults; and the elements of logistics support which are interdependent when considering diagnostics. Finally, since diagnostics need to be systematically matured, [testers] need to track and test them through their life cycle."

While the preceeding discussion could not possibly address all of the potential logistics activities related to materiel readiness, it has, hopefully, given a different perspective to considering the relationships. For a more detailed analysis of the activities the program planner and decision maker should consider in logistics planning, a key reference to consult is MIL-STD-1388-1A, <u>Logistic Support Analysis</u> (11 April 1983). This standard identified the key analyses that must be performed in a comprehensive LSA and provides the basis for tailoring an ILS acquisition strategy. Extracts from this standard are in Appendix E.

In addition to these critical technical functional areas, another area of activity plays a key role in developing materiel readiness: Program Structuring and Management. This is the final functional area discussed in this chapter.

PROGRAM STRUCTURING AND MANAGEMENT

In designing a system emphasizing the ultimate readiness capability of the system, the Program Manager must recognize that certain generic factors will influence how best to set the program priorities. Among these factors are:

- variations in programs and acquisition environment,
- interrelationships and dependencies of program elements,
- concurrency, and
- scheduling.[10]

The first of these factors is discussed below. The other factors are discussed elsewhere in this handbook.

There are four main areas that come under the first factor mentioned above:

- type of system,
- expected operational environment and usage,
- technology aspects of the system, and
- the current acquisition environment.

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[10] The substance of this discussion is based on information and ideas contained in the IDA/OSD Reliability and Maintainability Study, Volume III, Case Study Analysis, Institute for Defense Analyses, November 1983. Unless otherwise stated, all quotations are from that volume of the study.

1. <u>Type of System</u>

The type of system (i.e., electronic or mechanical) being acquired will significantly infuence the parameters which are used to define the required R&M/readiness capability of the system, since some elements, goals or requirements are more applicable to some types of systems than others. Examples would be thermal analysis applied to engines and radars; derating criteria in electronics; and margins of safety or allowable material strengths applied to engines and airframes.

2. <u>Operational Environment</u>

The operational environment also influences the system R&M, since the same system, subsystem or component may vary significantly in reliability depending on the system in which it is installed and how that system is used. This means that "...there is inherent uncertainty in attempting to translate field occurrences to design features/attributes of one program for use in planning another program without first attempting to understand the many subtle, but potentially major, impactors."

Variation in the placement of a system on different platforms may also have a significant influence on reliability-related design features, and in the ultimate reliability of the system. An example is the 20mm Gatling-type M61-A1 gun, installed in the F-15, F-4E, F-16 and F/A-18. This gun is installed in a different position in each of these aircraft, and as a result is subject to different forces and stresses. The potential affects of different configurations must be examined

not only in developing the initial analysis of the planned operational analysis, but also in integrating the gun characteristics and reliability capabilities in the overall aircraft design.

In addition to these variations, it is also necessary to consider the different operational environments for missions, particularly in joint programs. Air Force systems may be deployed virtually anywhere and the same basic system may have to operate under extremely different climatic and environmental conditions. Jointly developed systems, those developed in conjunction with the other Services, may compound this problem due to additional requirements to operate in different environments (e.g., salt and sea for Navy systems, and mud and sand for Army systems.)

3. Technology

"The evolutionary stage of the hardware/software involved and the degree of the state-of-the-art design in a system play a major role in attempting to structure R&M elements in a program." Analyses of the F-15 and F-16 radar systems development histories shows that the multi-stages, evolutionary development of the system allows for steadily increased reliability. These radars evolved through the adaptation of state-of-the-art technological advances in solid state circuitry, micro-processor development and the enhanced capabilities available to transfer previously mechanical/electronic functions to software (i.e., programmable signal processors (PSP)).

4. Current Acquisition Environment

The current acquisition environment, as evidenced in the Acquisition Improvement Program (AIP), DoDD 5000.1, DoDD 5000.39, and MIL-STD-1388-1A, emphasizes increased concern on system supportability and readiness in system design. In addition to these, there are a number of directives, instructions, standards, guides and studies which address particular aspects of the readiness/supportability picture. Many of these documents emphasize the need to:

- be aware of the multiple factors and interdependencies which relate to system readiness;
- plan for managing these interdependencies in a way that recognizes that coordination, communication, and intensive monitoring are necessary to comprehensively manage to maximize readiness;
- provide resources (personnel, funding, time) to allow for the effective and adequate consideration of readiness drivers; and
- begin planning and analysis of readiness-related requirements early in the acquisition; in Concept Exploration, and continue these efforts throughout the acquisition, analyzing field results after deployment.

Funding is a particular concern in maintaining an effective readiness-oriented program. Exhibit 4-18 shows the suggested funding profile for a program with the general trend which presently occurs in actual programs, by design phase. In programs funded for performing the necessary readiness-related activities early in the acquisition process, such as tradeoffs between R&M and performance, the funding curve would show a pattern with increased spending in the earlier phases. As shown in Exhibit 4-18A, what presently tends to occur is a much shallower

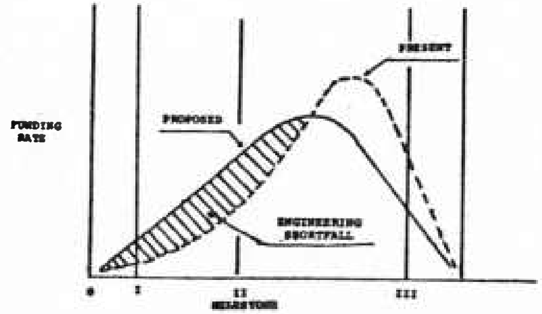


Exhibit 4-18a. FUNDING PROFILES

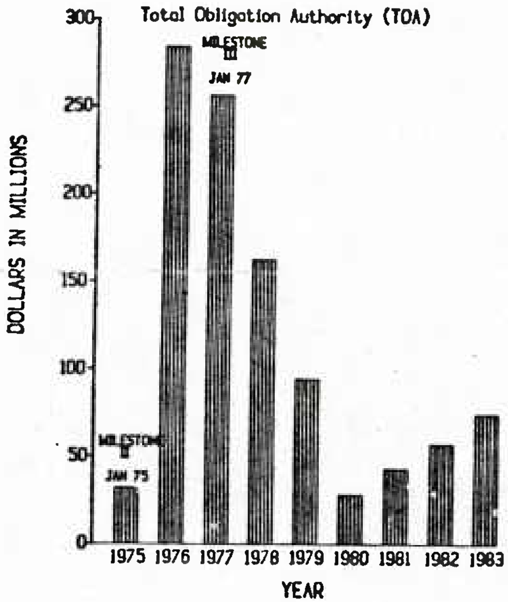


Exhibit 4-18b.
F-15 DEVELOPMENT
COST PROFILE

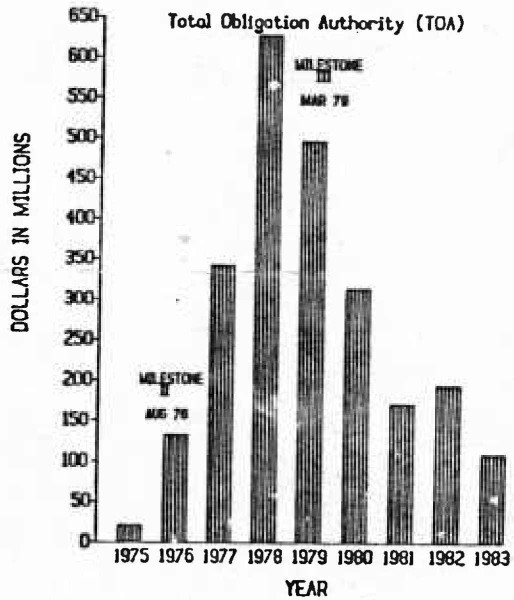


Exhibit 4-18c.
F-16 DEVELOPMENT
COST PROFILE

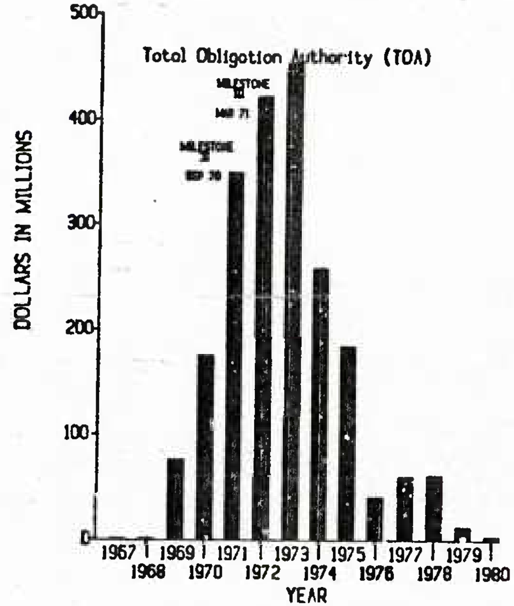


Exhibit 4-18d.
F/A-18 DEVELOPMENT
COST PROFILE

Source: IDA/OSD Reliability and Maintainability Study, Vol. III, Case Study Analysis

Exhibit 4-18. SUGGESTED VERSUS ACTUAL FUNDING PROFILES

funding curve, with significant emphasis on the late FSD Phase activities and early Production Phase. Such emphasis means that cost benefits accrued by early identification and analysis of high risk elements may not occur. While these risks may ultimately be resolved, the resolution may be accomplished much later in the pogram and, therefore, at a much higher cost. In terms of fixing problems and reducing risks, time does mean money.

Emphasizing front-end analysis also means considering approaches for maturing the design and technology earlier in the program. The following quote explain why this is seen as a useful approach.

"For programs with severe budget constraints, consideration must be given to focusing on front-end design activities to develop high design potential and then planning for an extended R&M growth/maturation program, using data obtained from production and field usage to identify problems and establish design fixes....Starting a growth program with a more mature design and growing the diagnostics, simultaneously, is a promising approach favored by many experts....

"In the past it is not uncommon to begin growth testing with an immature design. Test time was wasted identifying the major faults that could have been eliminated with a stronger up-front effort. This up-front effort would facilitate more efficient use of test resources to identify the latest problems that design analysis will not detect....With the present funding profile, the designer's innovative and creative thinking can be severly constrained by schedule. His primary emphasis is to put a system together that functions with a minimum of effort and to develop a design which not only functions but also does so with a low failure rate. This constraint currently forces the designer or program manager to delay the development of a diagnostic system until well into the testing phase, a major problem identified in [several] case studies."

Another element of the current acquisition environment is the set of current acquisition policies. A major driver of the system's ultimate readiness capability when fielded is the

reigning acquisition policy regarding overlapping of start of production and completion of the FSD Phase testing. The previous policy of "fly before buy" minimized the use of concurrency in these phases and instead emphasized completion of development and final Operational Testing II before initiation of full production. This allowed adequate time to develop the system, test it, and fix problems before production. The Army's T-700 Engine, used in the AH-64 Apache and UH-60A Black Hawk helicopters, is an example of such a program. While the engine and the user aircraft had concurrent FSD Phases, much development work occurred in the early engine development program. The engine was developed over a 12 year period and the adequate funding of this development process is seen as a major reason for the engine's success.

In order to allow for adequate development of a readiness capability, concurrent programs (examples of which are the F-15, F-16 and F/A-18) must be structured so that:

- R&M activities are implemented early in the program (i.e., Concept Exploration Phase) and given emphasis throughout the program,
- R&M design disciplines are enforced up-front, and
- an R&M growth program is implemented to extend through the FSD Phase into production.

SUGGESTED READINGS

- Operational Readiness of High Performance Systems. Defense Science Board. 1982.

- Report of the Defense Science Board Task Force on Transition of Weapon Systems from Development to Production. Defense Science Board. May 1983.

- Solving the Risk Equation in Transitioning from Development to Production. Defense Science Board Task Force on Transitioning from Development to Production. 25 May 1983.

- IDA/OSD Reliability and Maintainability Study. Institute for Defense Analyses. November 1983. In four major volumes with 24 additional volumes documenting case studies, R&M Program Review Elements and Parameters, and technology working group reports.

- Brooks, Frederick P., The Mythical Man-Month: Essays in Software Engineering: Addison-Wesley Publishing Company. 1982 edition.

- Defense Systems Management Review. "Test and Evaluation Issue." Volume 1, Number 5. Defense Systems Management College. Ft. Belvoir, Virginia. Winter 1977.

- Defense Systems Management Review - Defense Acquisition: The Process and the Problems. Volume 2, Number 4. Defense Systems Management College. Ft. Belvoir, Virginia. Autumn 1981.

- Concepts. "Program Management Issue." Volume 4, Number 1. Defense Systems Management College. Ft. Belvoir, Virginia. Winter 1981.

- Concepts. Volume 4, Number 4. Defense Systems Management College. Ft. Belvoir, Virginia. Autumn 1981. Articles on financing defense programs, the DoD Acquisition Improvement Program, human factors in system design, and scheduling for program management.

- Concepts - Special Issue: The DoD Acquisition Improvement Program. Volume 5, Number 3. Defense Systems Management College. Ft. Belvoir, Virginia. Summer 1982.

- Concepts - Special Issue: Managing Software. Volume 5, Number 4. Defense Systems Management College. Ft. Belvoir, Virginia. Autumn 1982.

CHAPTER 5. CONCURRENCY-RELATED ACTIVITIES

- Specification Development and Design Reviews
- Full-Scale Development Testing and Production
- ILS Element Development

CHAPTER 5. CONCURRENCY-RELATED ACTIVITIES

Concurrency can be used in a variety of different applications within a program. As discussed in Chapter 2, the term itself can be interpreted to mean:

- parallel (back-up) technological development;
- simultaneous, but independent, subsystem development and testing;
- co-production; and
- overlap of dependent, normally sequential activities.

The last interpretation is the one applied in this handbook. It can also be applied to different magnitudes within the program, (determined by how much the activities overlap), and at different levels of tasking - from overlapping acquisition phases, to overlapping tasks associated with level six activities in a WBS.

This chapter focuses on the major kinds of materiel readiness-related activities which tend to be concurrently scheduled. Some of these activities have been discussed in light of their concurrency considerations in the preceeding chapter. The activities discussed in this chapter are only some of the total number that can be concurrently scheduled. However, they are activities which, if not closely managed, can cause significant impacts on readiness. The reader should use this discussion as a starting point from which to examine materiel readiness implications of his or her particular concurrency decisions.

Three major activities are discussed in this chapter:

- **SPECIFICATION DEVELOPMENT AND DESIGN REVIEWS**, as critical activities in the Requirements Formulation and the design and development of the system;

- **FULL-SCALE DEVELOPMENT TESTING AND PRODUCTION**, the form of concurrency most frequently discussed; and

- **ILS ELEMENT DEVELOPMENT**, particularly the development of the maintenance facility.

These activities are discussed in terms of the potential impacts of concurrently scheduling them, not how they should be scheduled. The next part of the handbook, comprised of Chapters 6, 7 and 8, examines that concern.

SPECIFICATION DEVELOPMENT AND DESIGN REVIEWS

In Chapter 4, the discussion of the requirements formulation process included brief descriptions of the major elements of developing requirements documents:

- the development of specifications documenting the system requirements and design characteristics,

- the maintenance of design baselines as a mechanism for configuration management and control, and

- the conduct of periodic reviews of the hardware and software design documentation.

The specific schedule for developing and reviewing these is left to the Program Manager. In terms of concurrency, this means that the overlapping of design activities and the conduct of the reviews can produce significant problems in configuration management.

A product of reviewing the design is frequently a need to conduct further analysis of some aspect of the design. This is

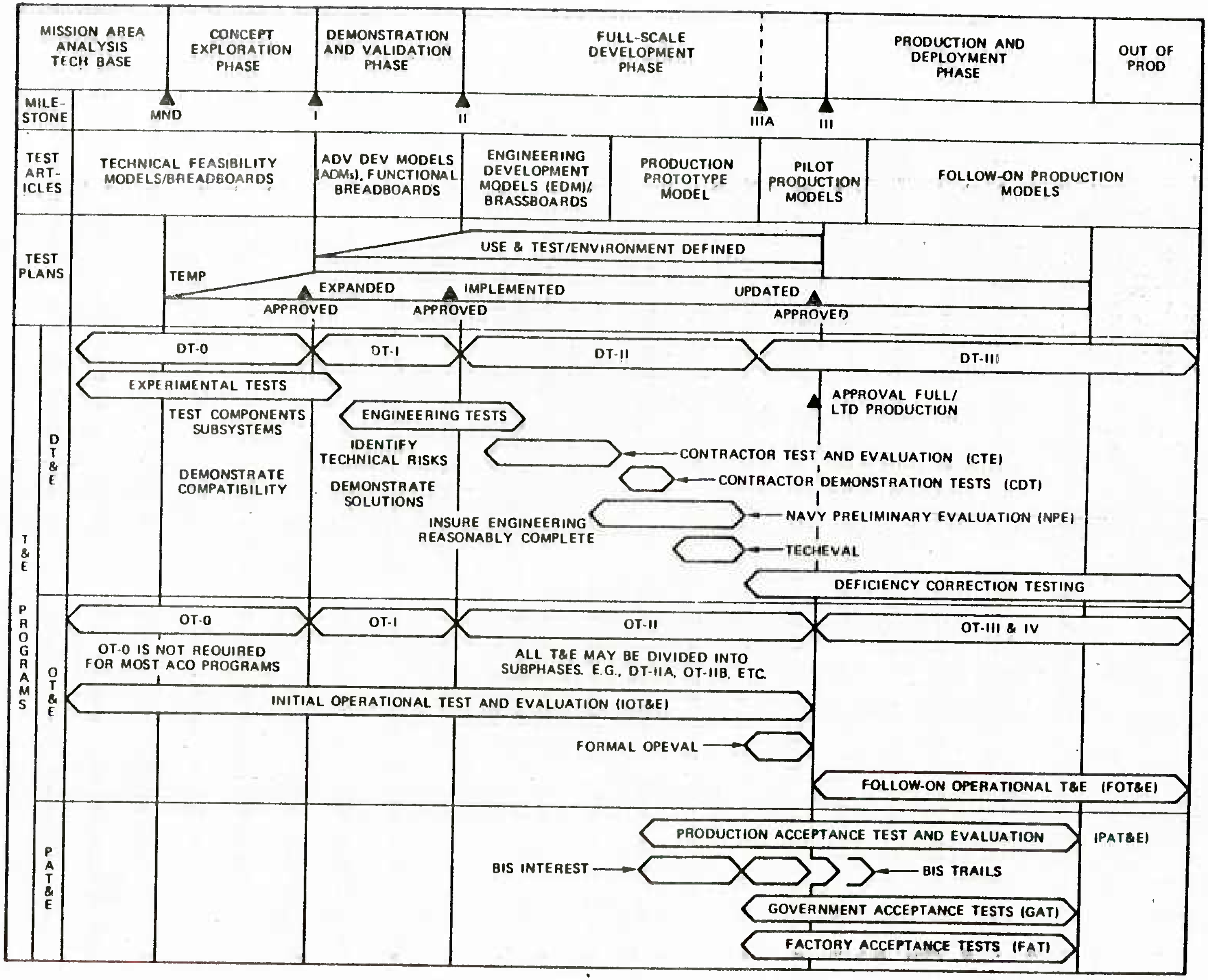
most frequently the case in programs applying new, immature or developing technologies, where the technological risks are much higher. The configuration is in a state of flux in that:

- portions of systems may be under revision, and there may be numerous revisions of some parts of the system, while other parts are fairly stable, more mature, and not representing as many unknowns;
- the capability to communicate the status of the various interdependent activities is taxed if there is not a management information system sufficiently responsive to the need, already in place;
- the jurisdictional conflicts between different functional areas that occur due to unclear delineation of responsibilities results in confusion as to the interpretation and ramifications of the status of critical configuration items.

The ability to schedule review of the specifications not at the end of the phase in which they are completed, but in the beginning of the succeeding phase means that contractual vehicles may be developed that are based on designs that may change.

FULL-SCALE DEVELOPMENT TESTING AND PRODUCTION

By far, the most critical and highly visible of the activities that can be concurrently scheduled are the test and evaluation (T&E) activities and the production design decisions. Exhibit 5-1 shows the basic relationship of T&E in the system acquisition. Developmental testing and operational testing are run largely concurrently. There are advantages and disadvantages to this, as discussed in the following quotes from the IDA/OSD Reliability and Maintainability Study, Volume III, Case Study Analysis.



Source: Navy Program Manager's Guide, NAVMAT P-9494, Naval Material Command, July 1983

Exhibit 5-1. RELATIONSHIP OF THE T&E PROGRAM TO THE SYSTEM LIFE CYCLE

"An area where schedule dependencies is very important is during the test and evaluation phase. In the case of the F-18, the reliability development tests were run concurrently with the total aircraft full-scale development tests. The same generation of hardware was tested in both programs. Some additional problems were identified in the development test, but had it been run earlier in the program, the full-scale testing could then have been done on the next generation hardware, thus giving feed-back on the corrective actions found and implemented during development testing and identifying problems on the next generation of hardware prior to delivery to the fleet. Corrective actions found during the concurrent testing were not incorporated until later deliveries. Indications from these later deliveries show the APG-65 [radar] to have a field reliability approaching 40 hours versus the 24 hours reflected in the case studies. Had the development test been run earlier, this improvement would have shown up during the full-scale development test and on the first units delivered, but the fact of test concurrency allowed the systems to be fielded earlier than with sequential testing."

"If the dependent work is begun or completed prior to the independent work which feeds the system, the amount of difficulty later encountered is a function of the accuracy of the assumptions made. If some of the assumptions are significantly in error, management is faced with a redesign effort, accepting the consequences, or something in between. Many times the cost and schedule consequences or redesign would probably be unacceptable. Therefore, something is done which produces less than the desired results. Additionally, the work done out of sequence uses the available resources ineffectively. An example of this is the failure modes, effects, criticality analysis (FMECA). When this is done off-line after PDR, it is unlikely to significantly affect design for diagnostics or the elimination of single-point failures."

While the situation discussed above is not the only outcome of FSD/production concurrency, it indicates a set of circumstances which can occur. There are two studies recently completed by the Defense Science Board regarding transitioning from development to production which address implications and provide suggested solutions for reducing the risks of these, including applications of concurrency. There studies are:

- Report of the Defense Science Board Task Force on Transition of Weapon Systems from Development to Production, May 1983; and

- Solving the Risk Equation in Transitioning from Development to Production, Defense Science Board, 25 May 1983.

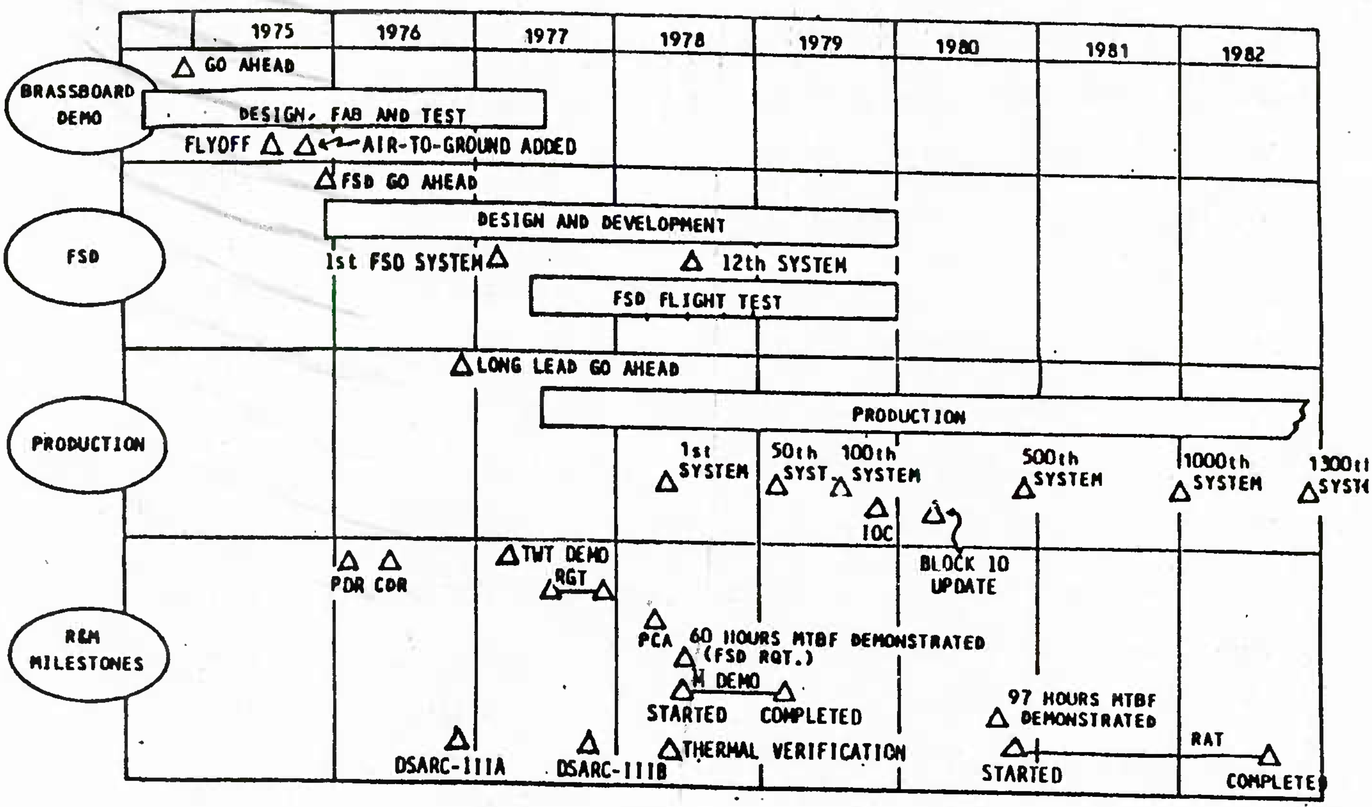
Additional sources of information on concurrency and T&E activities are referenced in Chapter 7 of this handbook.

ILS ELEMENT DEVELOPMENT

The variety and distribution of ILS elements means that concurrency among them is practically unavoidable. In applying concurrency to ILS development, the major concern is in the concurrency occurring between the hardware and software design activities and the ILS system development. This is a concern due to the problems with data availability to support the analysis.

As discussed in Chapter 2, the information flows in a program with concurrency are significantly more disruptive than in a program with very constrained concurrency. This means that the feedback between design activities is often limited. Compounding this issue is the difficulty in accessing useful data from other systems or from the test results.

In the preceeding chapter, the connection was made between the system design activities and ILS via the relationship between R&M and the diagnostic system. The ability to develop an improved, mature R&M capability, and the associated system diagnostics depends on being able to incorporate the results of a technology maturation program in the architecture and development of the ILS/diagnostic system. Exhibit 5-2 shows the concurrencu in the development and production schedules of the F-16 radars.



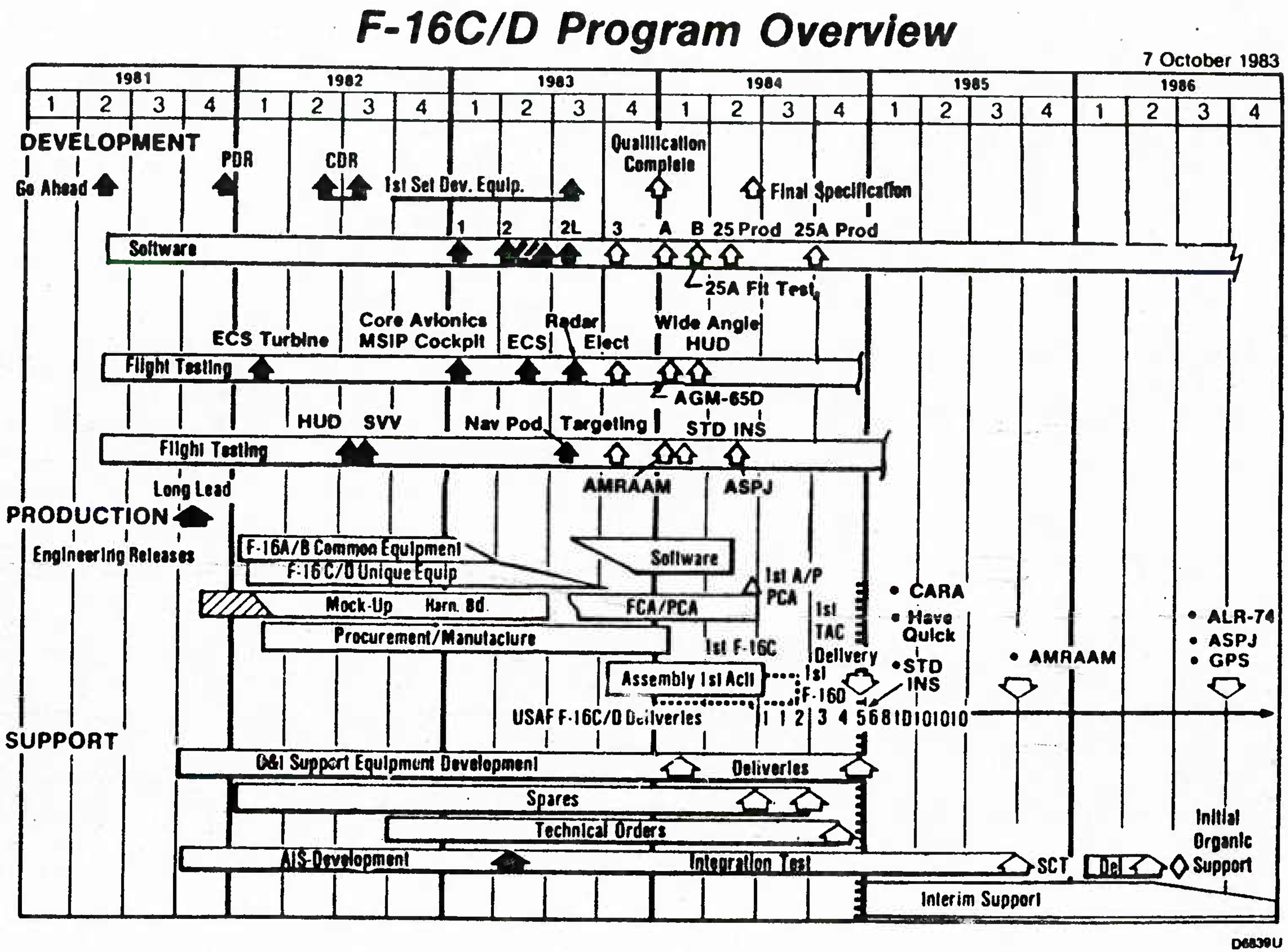
Source: <u>IDA/OSD Reliability and Maintainability Study</u>

Exhibit 5-2. F-16 APG-66 PROGRAM SUMMARY

Exhibit 5-3 shows the overall concurrency in the F-16 C/D program. Concurrency has been used throughout this program in all three strategy types: Planning or Scheduling, Management and Acquisition. The logistics concurrency has involved the concurrent development of the critical maintenance capability - the Avionics Intermediate Support (AIS) facility, and the non-AIS organizational and intermediate support. The trade-offs in developing this capability have, however, led to the need for extensive interim contractor support.

Missile systems, on the other hand, can tolerate much more concurrency than advanced technology aircraft programs, primarily because of the limited unknowns in the technology. The Peacekeeper Program has been able to sustain extensive concurrency because it has been able to build on the base of experience from the Minuteman Program. This, combined with an extensive, well-run management information feedback system, has allowed for the significant and successful use of concurrency.

The next section of the handbook discusses the scheduling analysis aspects of concurrency.



Source: Moch, W., "F-16 C/D Aircraft Integrated Logistics Support Program Summary," General Dynamics/Fort Worth Division, November 1983

Exhibit 5-3. CONCURRENCY IN F-16 C/D PROGRAM ACTIVITIES

Part III. SCHEDULING TECHNIQUES AND ANALYSIS

Chapter 6. Summary of Scheduling Techniques

Chapter 7. Structure of Concurrency Schedule Analysis

Chapter 8. Analysis of Concurrency Schedule Risk

PART III. SCHEDULING TECHNIQUES AND ANALYSIS

This part of the handbook focuses on the major scheduling techniques at the disposal of Project Managers (Chapter 6). Also included, in Chapter 7, is a description of an approach for conducting analysis of schedules in which concurrency is to be used. Finally, in Chapter 8, discussion of how the risks associated with concurrency can be analyzed is provided. The purpose of these chapters is to provide a centralized discussion of considerations the Program Manager should be aware of and some approaches for conducting analyses. Appendix E contains guidance on developing a scheduling network.

CHAPTER 6. SUMMARY OF SCHEDULING TECHNIQUES

- Planning and Scheduling as Program Functions
- Gantt Charts
- Milestone Schedules
- Networking

CHAPTER 6. SUMMARY OF SCHEDULING TECHNIQUES

PLANNING AND SCHEDULING AS PROGRAM FUNCTIONS

A significant concern of the Program Manager is the development of a program plan or acquisition strategy, and a set of program schedules. These requirements refer to related, but separate functions within the program office: Planning and Scheduling. Collectively these functions relate to a set of specific tasks:

- defining all the work or activities to be accomplished by all program personnel funded within the program budget;
- ordering the sequence in which all these activities should take place;
- determining the material and personnel resources which will be required to accomplish these activities.
- utilizing identified resources to determine the time required to perform these particular activities;
- summing up the periods of time identified for those activities to determine chronologically when those activities must be accomplished; and
- being prepared to rework these plans, revising the schedule, redistributing the resources, and changing the sequence of work as work is redefined or corrected.1/

Planning focuses on the identification of the tasks, activities, and events which must be performed in order to complete the program. Scheduling is the:

1/ Davis, Hugh E. and Young, Robert W., Planning and Scheduling Enhancement in the Acquisition Process at the Aeronautical Systems Division, Air Force Business Research Management Center, Wright-Patterson AFB, OH, November 1982.

"...process of obtaining the information on how long a job should take, relating it to the other jobs required to deliver the product, and laying out [these] data in a specific format to show when it must be done to fit all the [known] constraints."2/

There are many techniques available to the Program Manager to use to develop program schedules. These techniques can range in degree of detail provided, amount of input data, number of variables, number of activities/events which can be monitored, and variety of conditions that can be monitored. The decision-maker must determine which technique is most appropriate for his program, based on factors such as:

- the size of the program,
- the amount of resources available for performing the scheduling function, and
- the magnitude of activities and events to be scheduled.

Depending on these variables, the Program Manager, or more likely the Program Control Directorate working in conjunction with the functional directorate and the laboratory/contractor, selects a scheduling technique or techniques. It is possible that more than one technique may be used in the same program. The master schedule may be maintained using one graphic technique, while functional schedules for more complex areas, such as ILS, may use a more detailed, comprehensive, tracking approach. Generally speaking, however, it is desirable to plan to use techniques that are clearly compatible with each other and provide appropriate levels of detail. Too much detail on a schedule

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2/ Devenney, T., Mason, W. and Snell, W., Program Scheduling Handbook, Business Management Division, Electronic Systems Division (ESD/ACBB), Hanscom AFB, MA, March 1980.

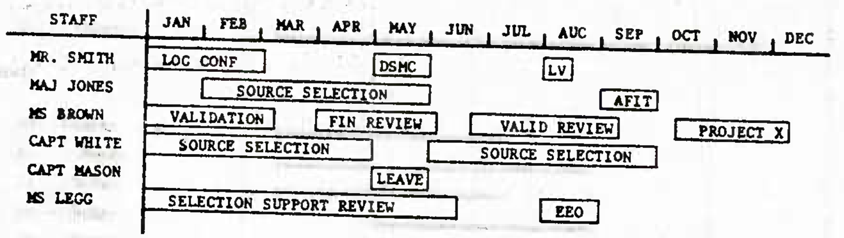
can be just as useless, or confusing, as too little detail if it impedes making meaningful decisions.

In this chapter, brief summaries are given of the major scheduling techniques available to the program office. The focus is on techniques providing differing amounts of information on the required sequence and relationships of program activities, and their status.

GANTT CHARTS

Gantt Charting is one of the earliest-developed approaches to schedule planning, and among the simplest. Information is portrayed in relation to the horizontal and vertical axes of a chart. The dependent data (activities, events, functions, etc.) to be scheduled are listed down the vertical axis. Time units (days, weeks or months) are listed across the horizontal axis. A bar is used to indicate the planned duration of the activity, stretching between the starting and ending points of time. Exhibit 6-1 shows several variations on Gantt Charts. Exhibit 6-1a shows the various responsibilities of staff members during a particular period of time. Exhibit 6-1b shows the duration of particular activities in an acquisition program, also by month, for a year. Exhibit 6-1c is a variation on this, showing activities for increments of months over a much longer period. Unlike the first two figures, this figure also illustrates an implied series of activities that are sequentially dependent (i.e., the first one must be completed before the second one can be begun.)

a.



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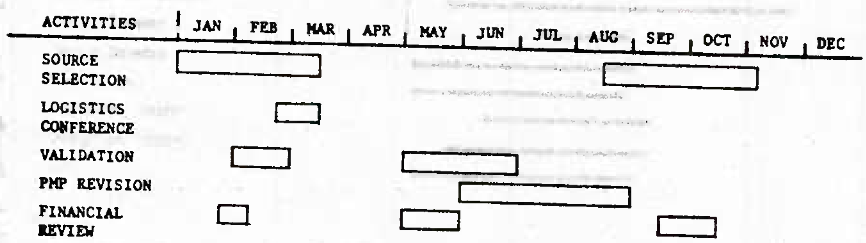
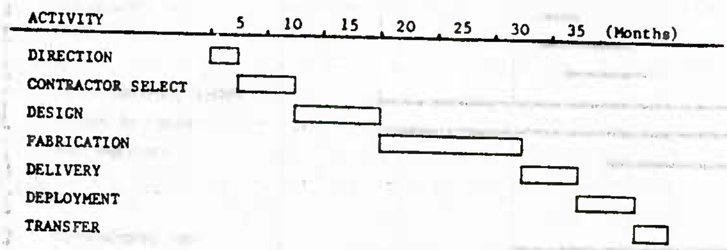
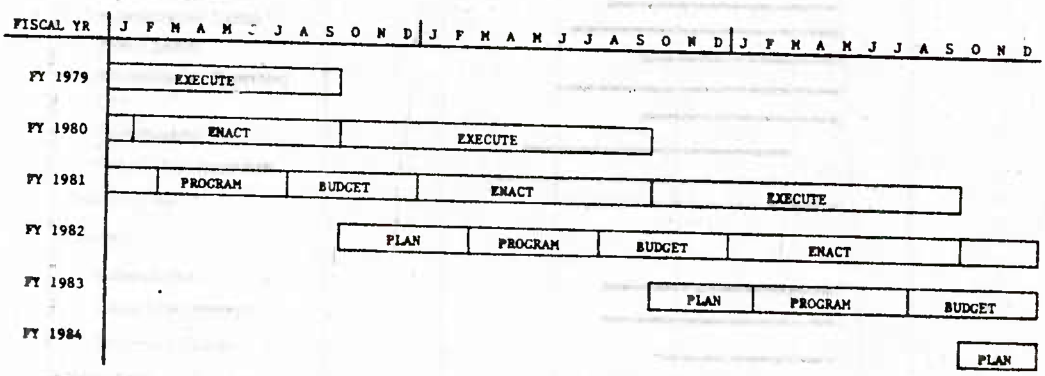


c.



d.



Source: Program Scheduling Handbook, ESD/ACBB, Hanscom AFB, Massachusetts, March 1980

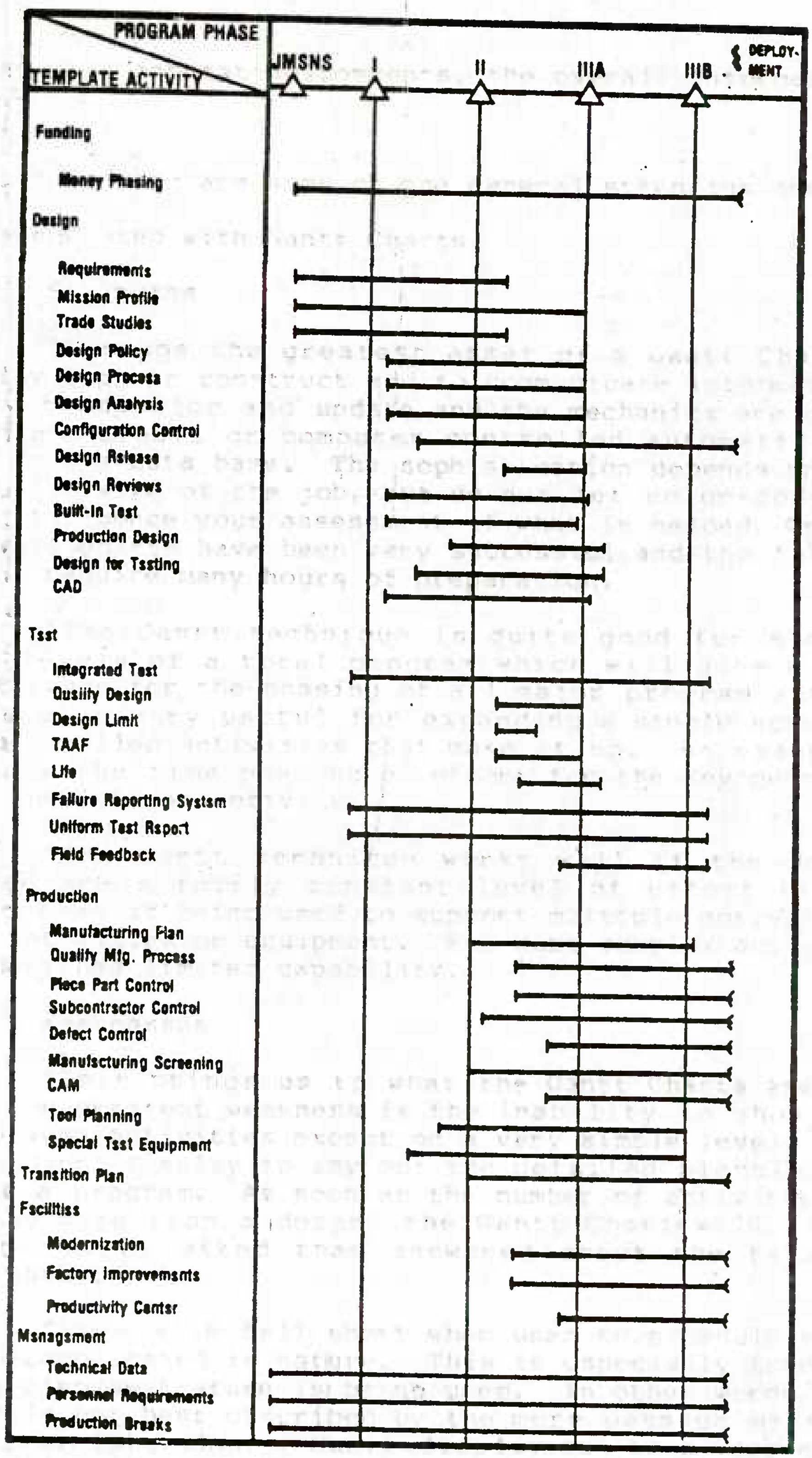
Exhibit 6-1. EXAMPLES OF GANTT CHARTS

This type of schedule is frequently called a "waterfall" schedule. Exhibit 6-1d shows the Planning, Programming and Budgeting System (PPBS) cycle across not only the calendar year but also across the fiscal period. This is a frequently used approach for illustrating the cyclic nature of the PPBS since the same sequence of activities is repeated annually as well as in parallel for multiple years.

Exhibits 6-2 and 6-3 illustrate two actual examples of the use of Gantt Charts. Exhibit 6-2 shows the suggested period of time, in the form of acquisition program phases, that analytical techniques should be used. As can be seen, only summary level information is provided. Additional detail would have to come from schedules developed for each of the template activities. Only general temporal relationships are shown.

In Exhibit 6-3 more information is provided in the form of codes to show the value to the program of conducting this particular reliability-related activity in a given phase. As with the previous example, no clear relationship between the activities is illustrated, although the start and end points allow for some interpretation. In this example, the codes have been used instead of a uniform bar to illustrate when an activity should be performed to optimize program success.

As can be seen from these two examples, the amount of information that can be conveyed by a Gantt Chart is fairly limited. Although more information concerning status can be conveyed than has been shown, usually through the use of a current vertical



Source: Solving the Risk Equation in Transitioning from Development to Production, the Defense Science Board, 25 May 1983.

Exhibit 6-2. EXAMPLE OF GANTT CHARTING: CRITICAL PATH TEMPLATE TIMELINES

Element	Life Cycle Phase				
	Conceptual	Validation	Full Scale Development	Production	Deployment
Requirements Definition	xxxxxxxxxx	xxxxxxxAAAA	A.........		
Reliability Model	xxxxx	xxxxxxxxxxx	xxxxx......		
Reliability Prediction	xxxxx	xxxxxxxxxxx	xxxxx......		
Reliability Apportionment	ooooo	ooooooooooo	ooooo......		
Failure Modes Analysis	ooooo	ooooooooooo	xxxxx......		
Design for Reliability	ooooo	xxxxxxxxxx	xxxxxxxxxxx	....	
Parts Selection	ooooo	xxxxxxxxxx	AAAAA.....	....	
Design Review	ooooo	xxxxxxxxxx	xxxxx......		
Design Specifications	xxxxxx	xxxxxxxxxxx	x.........		
Acceptance Specifications	xxx	xxxxxxxxAAA	A.........		
Reliability Evaluation Tests	---	xxxxxxxxxx	xxxxx		
Failure Analysis	---	xxxxxxxxxx	xxxxxxxxxxx	oooooooooo	oooooooooo
Data System	---	xxxxxxxxxx	xxxxxxxxxxx	oooooooooo	oooooooooo
Quality Control		oooooooooo	xxxxxxxxxxx	xxxxxxxxxx	oooooooooo
Environmental Tests		xxxxx	......AAAAA	A........	
Reliability Acceptance Tests		xx	........AAA	Aooooooooo	

First contract

KEY

------	Desirable activity (for highest success probability)
oooooo	Necessary activity (errors seldom disastrous)
xxxxxx	Very important activity (errors often disastrous)
AAAAAA	Critical activity (errors usually disastrous)
......	Low key activity (to update previous results)

Source: Anderson, R.T., Reliability Design Handbook, ITT Research Institute, Chicago, Illinois, March 1976

Exhibit 6-3. EXAMPLE OF GANTT CHARTING: RELIABILITY PROGRAM ELEMENTS

time line with annotating comments, the overall information is limited.

The following are some of the general strengths and weaknesses associated with Gantt Charts.

1. Strengths

"Perhaps the greatest asset of a Gantt Chart is its simplicity both to construct and to communicate information. They are easy to develop and update and the mechanics are compatible with pen and pencil or computer controlled automatic plotters working from a data base. The sophistication depends on the purpose and the size of the job, but do not let color-coded window dressing influence your assessment of what is needed. Grease pencil on wall charts have been very successful and the fancy presentations require many hours of preparation.

"The Gantt technique is quite good for showing the summary levels of a total program which will give a quick one page reference for the phasing of all major program activities. They are also very useful for expanding a single schedule task into the detailed activities that make it up. An example would be to show the time phasing of effort for the key people necessary to complete an activity.

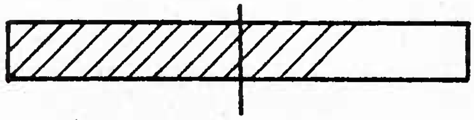
"The Gantt technique works well if the activities scheduled are a fairly constant level of effort or a fixed resource that is being used to support multiple activities, such as test facilities or equipment. For more complex activities the Gantt Chart has limited capability.

2. Weaknesses

"This brings us to what the Gantt Charts are not good for and the greatest weakness is the inability to show interactions between activities except on a very simple level. Don't try to use a Gantt display to lay out the detailed planning for any phase of a program. As soon as the number of activities becomes large (say more than a dozen) the Gantt Chart will cause more questions to be asked than answered about the relationship between tasks.

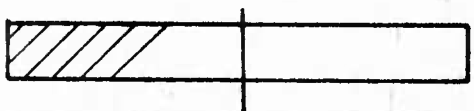
"They also fall short when used to schedule activities that are complicated in nature. This is especially true when the progress display feature is being used. In other words, when the activity is not best discribed by the mere passage of time from start to finish, then a Gantt display can be a very misleading way to monitor performance. The following are a few examples of the confusion that can arise.

a. The task is front-loaded in terms of the effort and material resources required.



The display shows an ahead of schedule situation when it is in fact on-time; it should be 75% complete at this point. In some cases it could be behind schedule depending on how front-loaded the task is.

b. The bulk of activity is required toward the end of a task.



The task may be ahead of schedule, but shows up as late.

"The point is that a Gantt technique is not designed to easily show completion progress on complex tasks and you can spend a great deal of time explaining artificial performance variances which detracts from the analysis of the real situation.

"The Gantt approach is also deficient in showing actual performance versus the original planned schedule baseline. If the start and completion dates are different than the plan, there is no simple way to display that information."3/

MILESTONE SCHEDULES

Milestone Schedules are a variation on Gantt Charts. It expands on the bar chart concept by including milestones or events as indicators of progress. Schedules are developed showing, for specific functions or sets of activities, key events

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3/ This discussion of strengths and weaknesses is extracted from the Program Scheduling Handbook, ESD/ACBB Hanscom AFB, MA, March 1980.

and when they are intended (or must) take place. Frequently a set of milestones for a specific function, such as program planning, are given on the vertical axis with symbols used to indicate the planned and actual status. A variation on this is to show several activities on the time bar. The milestone schedule improves on the Gantt Chart by providing information on the status of the actual performance, showing the relationship of the actual status to the baseline schedule, and allowing for changes in the future plan.

In order to effectively develop a milestone chart, significant program planning must be accomplished. Unlike the Gantt Chart, which focuses on very summary-level data, the milestone chart is intended to indicate the status of lower level activities. In the case of Gantt Charts, there may or may not be lower level activities. Milestone charts are, in the context of program management, intended to indicate that much more information is behind them. However, like the Gantt Chart, the milestone schedule is a status monitoring tool, not a forecasting technique (i.e., network analysis). One cannot extrapolate the potential status of activities and resources given the information on a milestone chart.

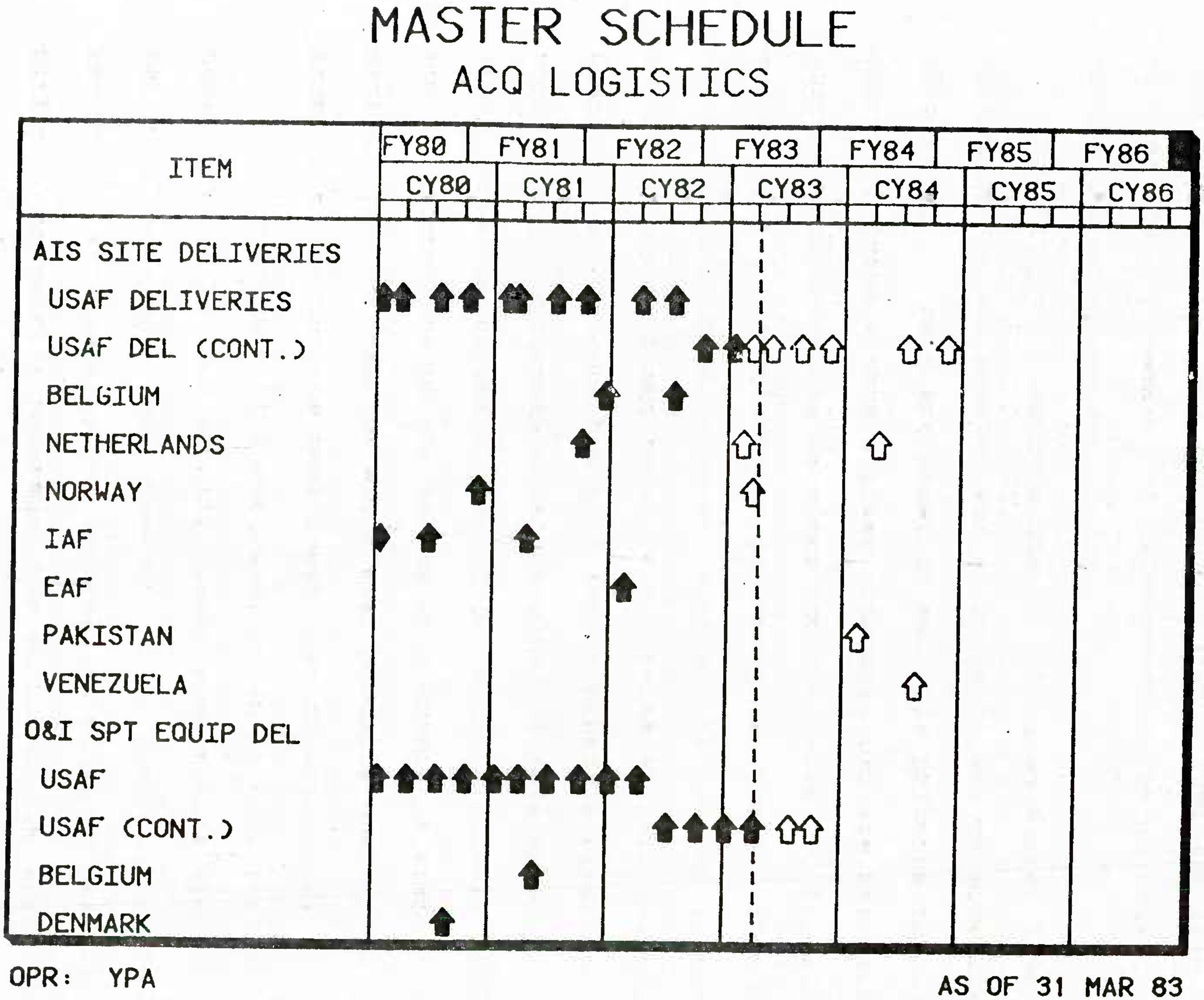
A major use of milestone schedules is to construct hierarchies of functional schedules for programs. They can be used to cross reference activities, events, functions, staff responsibilities, etc. and can be very easily tied to the Program Work Breakdown Structure (WBS). The WBS is the widely used structure for segmenting program activities, the system, and subsystem

components, into specific strata and functions. Program costs are usually related to WBS elements, as are many risk analysis techniques.

Exhibits 6-4 through 6-6 show examples of actual applications of milestone schedules from the F-16 Master Program Schedule. Each of these provides varying information in addition to the status of an activity for a specific period of time. Exhibit 6-4 illustrates the status of several F-16 Avionics Intermediate Support (AIS) site deliveries as of a specific period of time. The black arrows show completed deliveries, while the white arrows show deliveries still to be made. At the time of the analysis, three of the site deliveries were behind schedule. In some variations on this type of chart a brief explanatory comment may be given on the same line, providing clarifying information on the status.

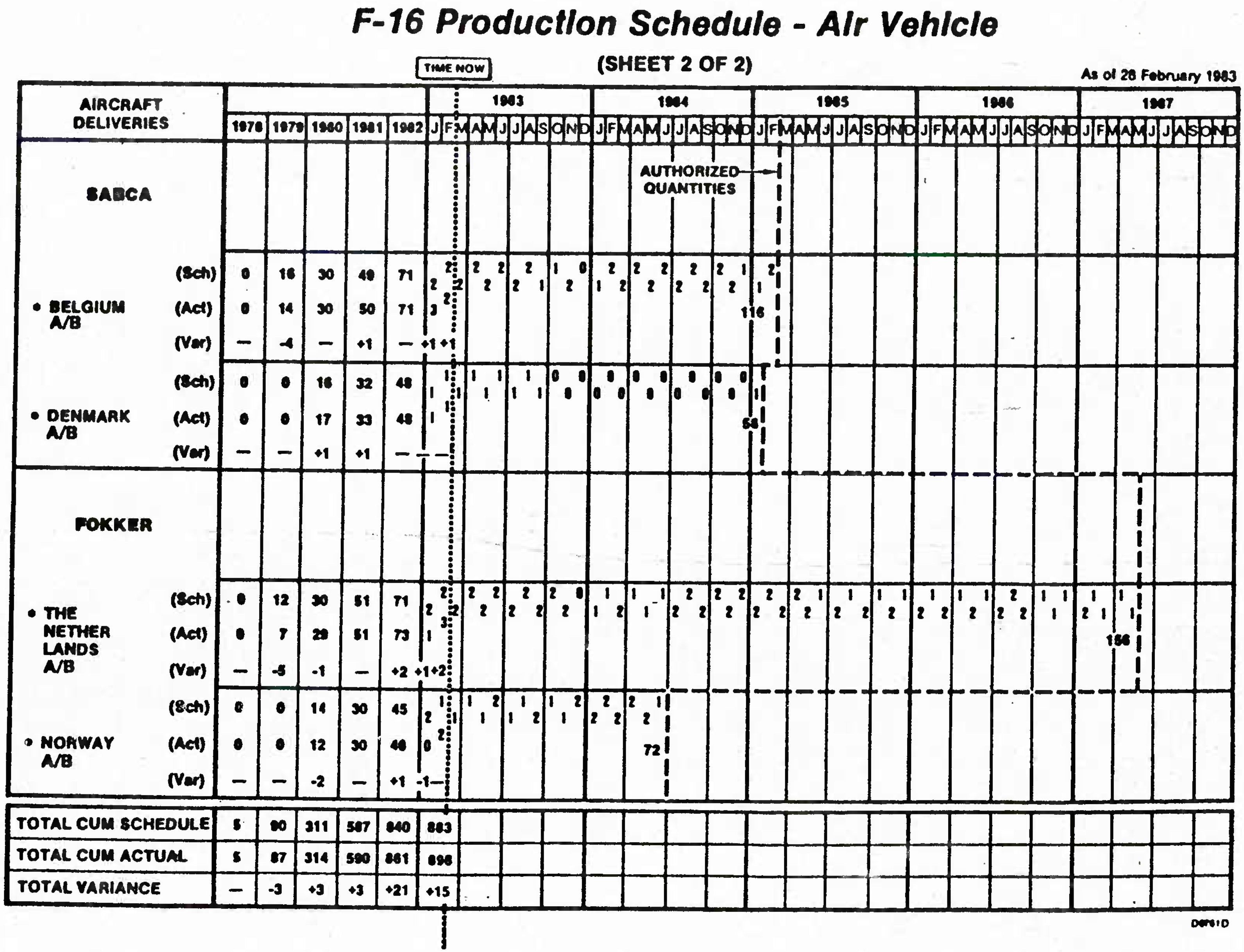
A variation on this is to note interim completion values. These values, usually in the form of percentages of work completed, are assigned to specific interim milestones for the activity. These milestone values are assigned when the schedule is developed and may be used as the baseline with which to compare the various progress calculations as the schedule advances.

Exhibit 6-5 provides somewhat more information. For each set of aircraft to be delivered, the monthly scheduled and actual deliveries are shown, along with the variation (plus or minus) between the two. The total projected or authorized quantities are also shown for each country. The monthly status is



Source: Master Schedule, F-16 Multimission Fighter System Program Office (ASD/YP), 31 March 1983

Exhibit 6-4. EXAMPLE OF GANTT CHART: F-16 ACQUISITION LOGISTICS MASTER SCHEDULE



Source: Master Schedule, F-16 Multimission Fighter System Program Office (ASD/YP), 31 March 1983

Exhibit 6-5. EXAMPLE OF GANTT CHART: F-16 AIR VEHICLE PRODUCTION SCHEDULE

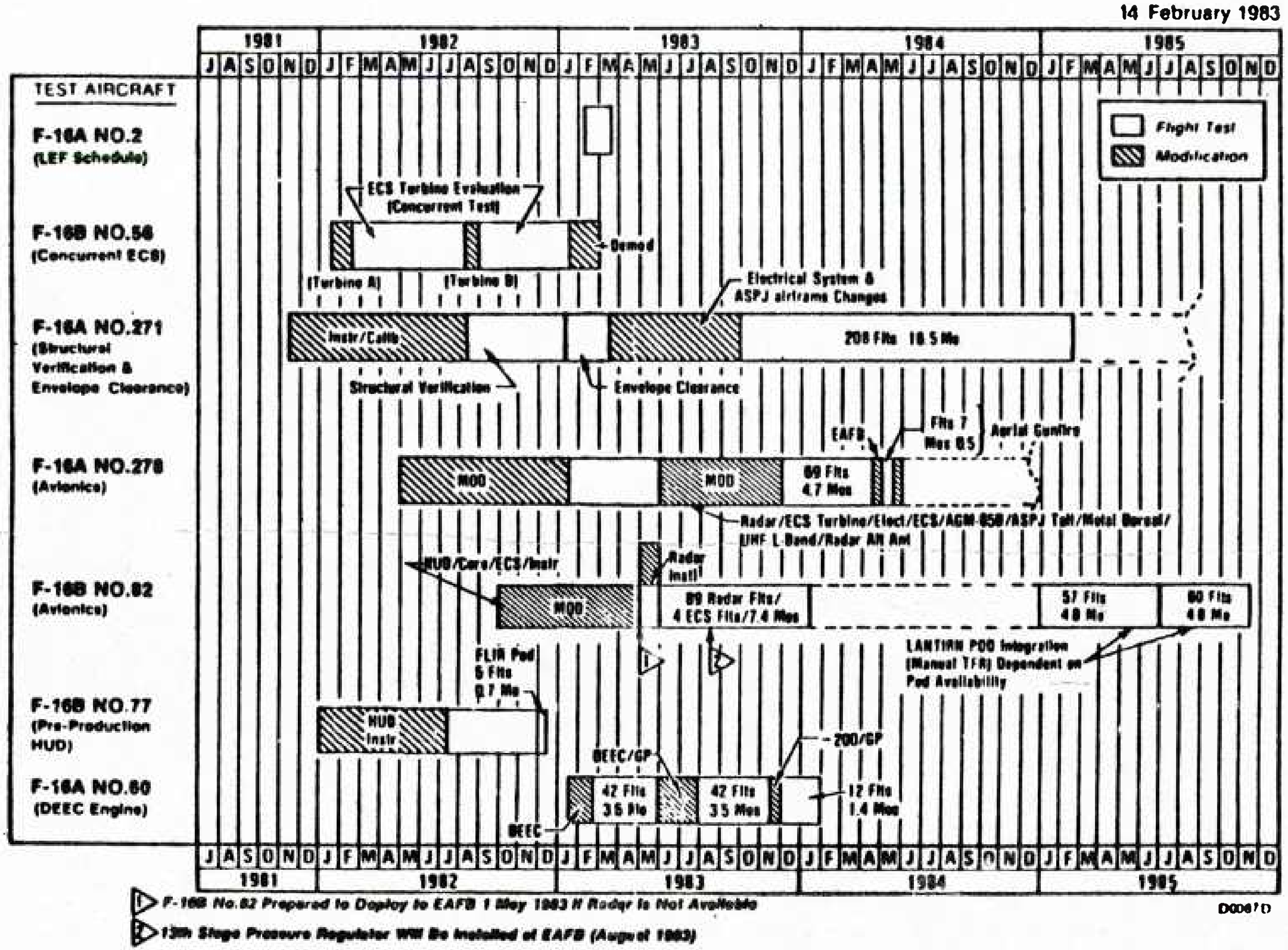
summarized for the cummulative schedule, actual and variances given. This additional information allows for significantly greater understanding of the status of a number of specific and similar activities and can support a more comprehensive overview of a schedule. However, it is successful largely due to the similarity among the activities.

Exhibit 6-6, also from the F-16 Program Master Schedule, illustrates still another variation on milestone schedules. In this schedule, bars are shown in multiple patterns to illustrate different tasks within a given category, and are annotated. Concurrent engine testing is noted for the F-16B No. 56, with alternating test and modification periods shown for all of the test aircraft. Each task is shown, with a duration and in some cases contingency conditions noted (e.g., F-16B No. 82, Avionics.) Compared to the other two F-16 Master Schedule examples, much more specific information is contained on this schedule. Such a chart, while being useful for illustrating a planned schedule is not as informative on the status of progress in completing the tasks. That information would most probably need to be obtained from schedules for the next lower tier of activities.

The importance of these examples is to note that milestone schedules can be used to effectively communicate specific information of varying types. However, it is also easy to "overload" bar charts with descriptive information so as to make it very difficult to quickly determine the status of the activities.

The following brief summary of the strengths and weaknesses of milestone schedules has been extracted from the ESD/ACBB

Flight Test Plan



Source: Master Schedule, F-16 Multimission Fighter System Program Office (ASD/YP), 31 March 1983

Exhibit 6-6. EXAMPLE OF GANTT CHART: F-16A/B FLIGHT TEST PLAN

Program Scheduling Handbook. While this may not be an exhaustive accounting of these characteristics, it does clearly and concisely describe the major ones of concern to program decision-makers. Also included is a set of suggestions on cautions to the Program Manager concerning developing and maintaining schedules.

1. Strengths

"As with the Gantt chart, the milestone schedule can be a very effective method of communication. The symbology is relatively standard and simple to use. It also allows the presentation of actual progress against a baseline plan and changes in future plans. The mechanics to construct milestone schedules are also relatively simple, although it may seem that we spend too much of our time with stick-on arrows and diamonds and the AFSC Form 103....Most of our contractors use milestone schedules extensively and they are usually the type submitted for the Program Schedule contract data item (data item description (DID) DI-A 3007) as well as their use in the Cost/Schedule Control Systems.

"As...more complex applications of milestone schedules are encountered we must remember that this scheduling approach is giving us a limited view of what is in fact a network of activities. Milestone charts are used to portray results derived from network analysis or a line of balance computation which is a variation of networking.

2. Weaknesses

"As with the Gantt chart, a major weakness of the milestone technique is the lack of a mechanism to show interdependencies or interaction between activities. Although milestone schedules are used extensively on complex programs, they are usually the product of some type of network analysis. In fact, the milestone technique is a good way to display various areas of a network in a more familiar form....The danger lies in our tendency to focus on the milestone format and lose sight of the true complexity of the relationship between the tasks we are dealing with and the total program.

"...A milestone schedule that shows all of the major events for [a] WBS item...is backed up by functional schedules from [each of the] responsible organizations. Each of these organizations must accomplish certain key activities to complete testing for this system. The milestone technique will not tell us what the sequence of activities must be, where the constraining points are, and which activities are most critical for management attention. In fact, there will be many opinions about

the above information, but the manager will be left to sort it out. The milestone technique will not show it to us.

"This type of problem becomes non-trivial quickly as the WBS level being scheduled increases. There is an ever-present danger that activities which show up on product (WBS) oriented schedules and on several different functional schedules may change in one place while the impact in other areas is not realized until too late. Again, milestones do not depict interactions, the manager must find them out.

3. Program Manager Cautions

"Most programs require the contractor to submit milestone schedules. The contractor is generally expected to select the milestones which he or she believes will indicate the overall status of activities. The data item description normally allows the government to approve of the milestones which are selected for periodic reporting. BEWARE! There are many traps in this area. First, do not let the contractor report milestones which no one in the SPO understands. Avoid cryptic abbreviations. Avoid generating a host of alphabet soup. The schedule is meant to communicate information. It can not do that without careful selection of the milestones. If you don't understand every line in a contractor's schedule have it explained to you.

"Another danger to avoid is the tendency for "micro-management." For example, one of the writers [of the Program Scheduling Handbook] had a contract with a large contractor who had automated a technique for producing milestone schedules. Working with the SPO, generic milestones were identified for reporting. Since the SPO software engineers had expressed a requirement for Computer Program Component (CPC) level visibility below the Computer Program Configuratin Item (CPCI) level, a generic set of eight milestones were selected for each CPC. Milestones such as start and complete design, and start and complete coding were at first considered reasonable types of milestones. Not until the SPO had let the contractor implement this type of schedule did we realize that there were more than 400 CPCs and that the software milestones would therefore number 3200. Similar mistakes were made in other disciplines with a net result of a program milestone schedule which had 10,000 events. Needless to say, the presence of so many "trees" prevented anyone from even finding the "forest." Remember, micro-management can kill.

"Select milestones by having each functional Division Chief determine what he or she considers important. Keep count of the milestones that he is requesting and avoid the CPC reporting problem above. Get feedback on the utility of the first few schedules from each division and revise the schedule accordingly. Work closely with the contractor in developing a schedule which will communicate information. Your requests for changes to the

contractor's submission can be made as part of your official comments on the data item.

"Another problem with milestone schedules is in determining whether the time depicted for an activity is reasonable. Past experience on other programs or independent assessments by the SPO divisions are good techniques, but tend to be subjective because of the lack of a credible data base of historical experience. However, if your contract requires a Cost Performance Report (CPR) and the validation of the contractor's C/SCSC system, there is another method for determining the reasonableness of a particular schedule.

"The contractor's C/SCSC system is required to have a scheduling system which meets certain criteria. An essential criterion is the ability for schedules at the work package level to support and track to the schedules at the cost account level. Similarly, the cost account schedules must support and track to the intermediate schedules and to the master schedule. For any item on the milestone schedule, the contractor should be able to demonstrate that lower level schedules support this item. These lower level schedules can be reviewed upon request. If you are lucky enough to have a data accession clause on your contract, you can also request copies of the lower level schedules which support a particular time. However, beware once again of micromanagement. A $40M contract can have over 5,000 work packages - each with a schedule. Insure that you use these requests sparingly to support a one-time review of a critical area. Do not allow yourself to get dragged into the trees. On the other hand, don't be afraid to use this data. Spot checks help insure that the contractor's schedules are credible.

"Most milestone schedules from the contractor contain a narrative describing why changes occurred. This narrative is never complete and there is a tendency for SPO Divisions to bombard Business Management with data item comments such as "Why did this slip" or "Why will this item take three months?" Do not accept these comments blindly and forward them to the contractor. A SPO cannot afford to communicate with the contractor solely or even primarily through the monthly schedule. If someone has a question, let him call his counterpart at the contractor's and ask the question. The only times that formal questions should be included in your data comments are when the contractor refuses to provide an informal answer or when the SPO OPR wants the answer formally documented for some reason. These questions should be limited. Answering these questions can tie up a significant portion of the contractor's management resources - resources that could probably be better applied elsewhere.

"Milestone schedules require a significant amount of effort to generate. Searching out the status of an item consumes more time than making the chart. Answering questions adds to the time. If you have ever developed a set of milestone charts for a Program Financial Review or for an internal review you can

quickly appreciate the amount of effort required. Remember this when you ask the contractor to do something."

NETWORK ANALYSIS

Network analysis, or networking, refers to the group of scheduling techniques which are designed to expand on the basic activity/event/duration scheme of Gantt Charts and milestone schedules by including information on event relationships. This is somewhat akin to adding the dimension of depth to a previously two-dimensional description. Information on the interdependencies of events and activities and the precedence relationships are developed and described in scheduling with network analysis. (As noted in the previous discussion of milestone schedule weaknesses, networks are frequently what lay behind milestone schedules.) Exhibit 6-7 shows this evolution.

There are a wide variety of network analysis techniques. The most well known and widely used are the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT). PERT has, in turn, generated a number of variations including GERT (Graphic Evaluation and Review Technique), and VERT (Venture Evaluation and Review Technique), as well as versions emphasizing different evaluation aspects (i.e., TAC-PERT, and PERT-Cost).[4/]

There are certain characteristics that most network analysis techniques share, and it is useful to briefly review them before

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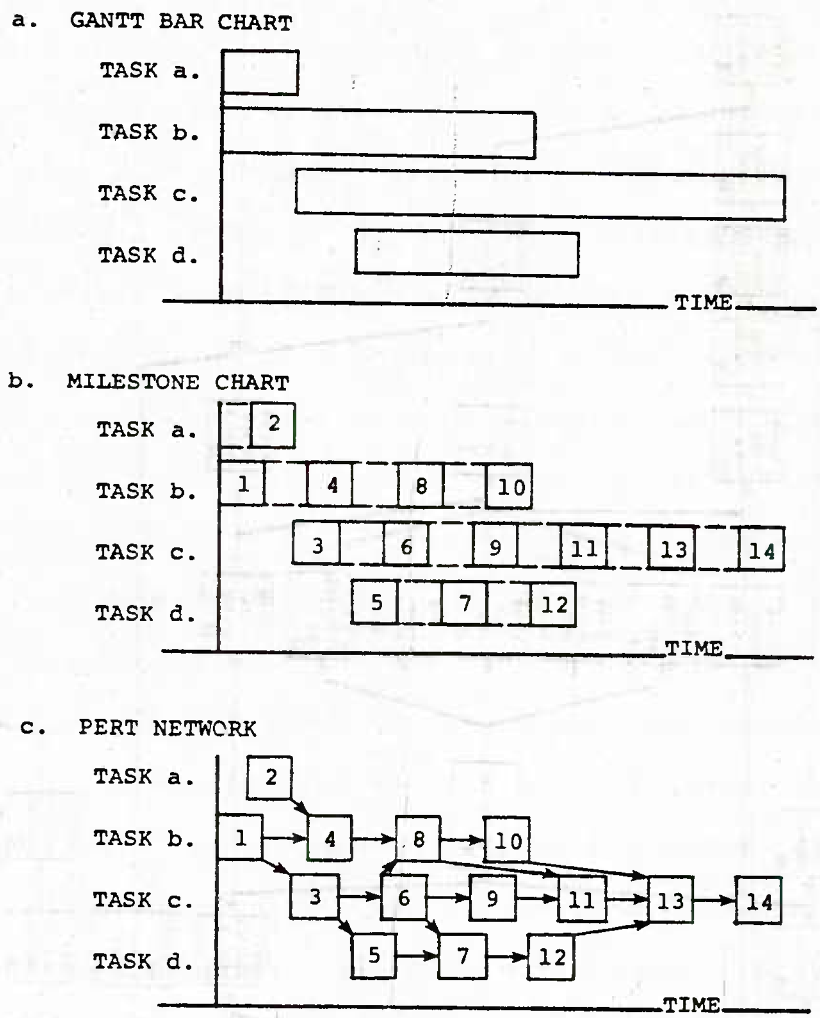
4/ There are numerous discussions on PERT, its variations and applications. Only a general discussion is included here, with some elaboration on risk applications of PERT in Chapter 10. For a more detailed discussion of PERT, one of many possible sources is An Analysis of PERT in Weapon System Acquisition, by Robert F. Ewart and Donald M. Nanney (AFIT, September 1974).



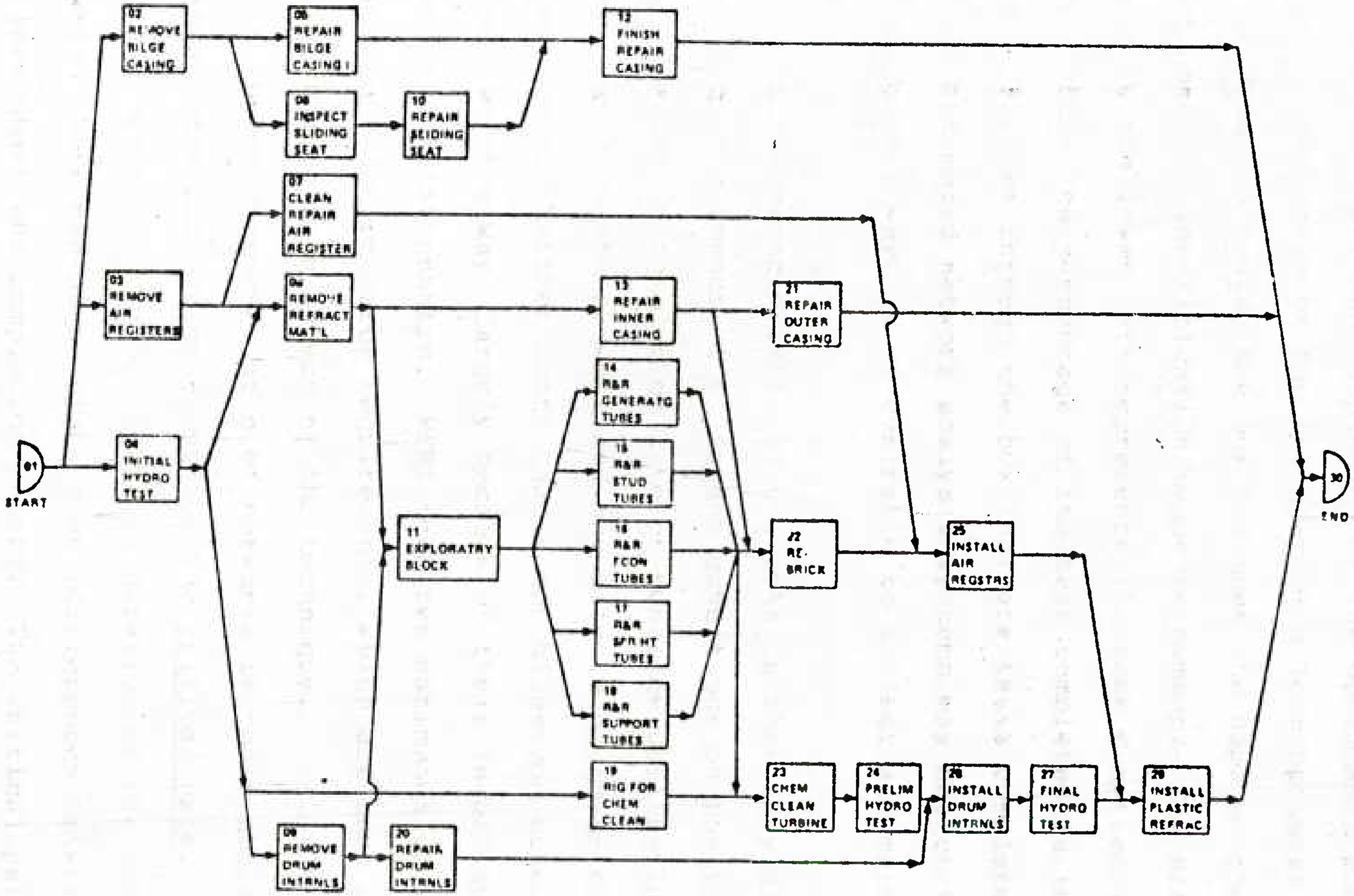
Source: Ewart, Robert F. and Nanney, Donald M., An Analysis of Program Evaluation and Review Technique (PERT) in Weapon System Acquisition, AFIT, September 1974

Exhibit 6-7. DEVELOPMENT OF PERT NETWORK FROM GANTT CHART

discussing any specific techniques. First, network analysis techniques are designed to integrate subschedules to show how portions of the project connect to one another. This means that dependency relationships among activities/events are identified. Information is developed on activities which must be completed before other activities can be initiated, or activities which are not explicitly dependent on other activities. This type of information is pivitol to the analysis.

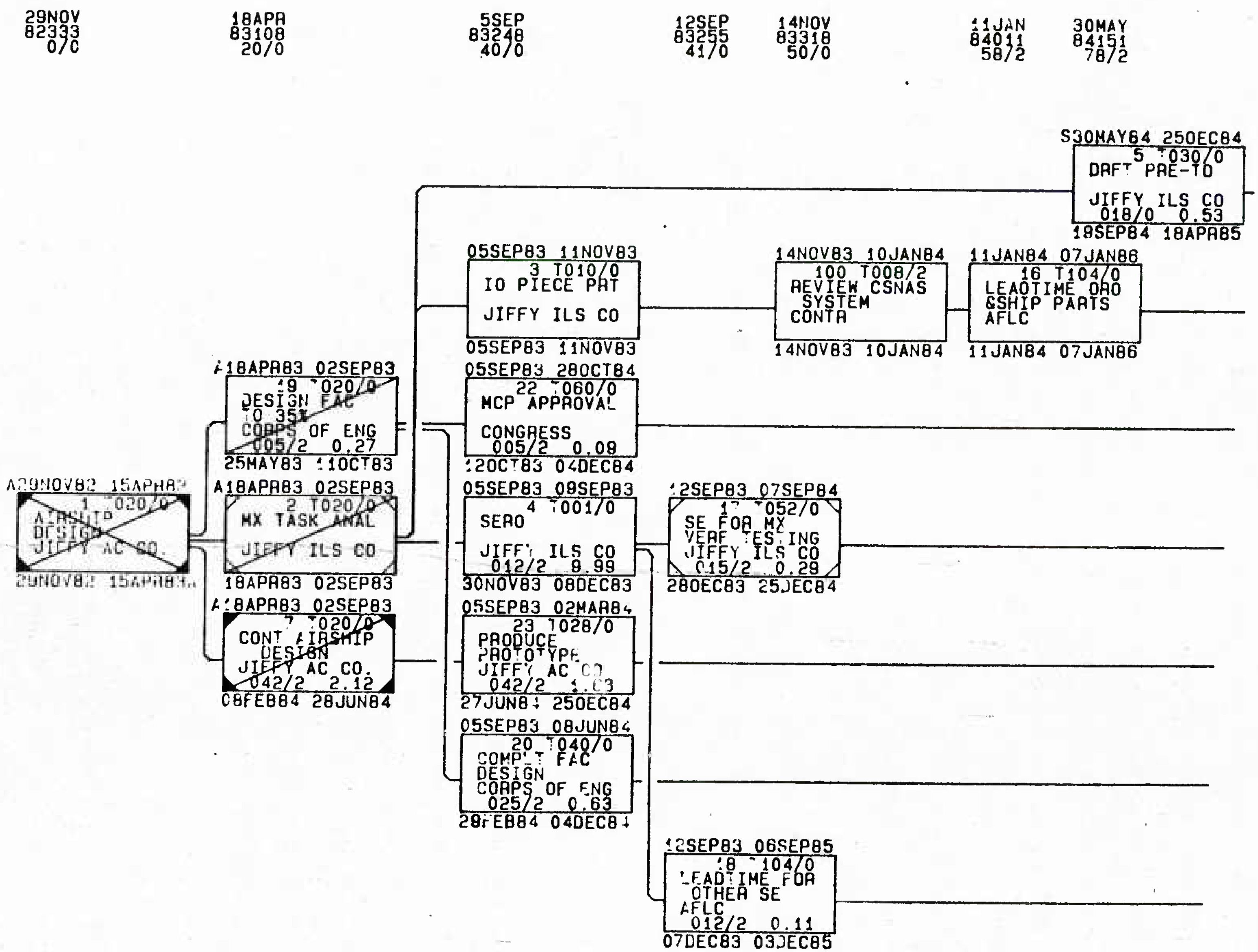
Second, in some form or another, networking usually involves some form of graphic representation of activities and events. This can take the form of nodes and arcs or lines connecting the nodes, or boxes connected by directional lines, or some similar form. In the first case the node, usually a circle or box, represents an event or milestone. The line between the milestones represents the activity initiated by the event or the goal of the activity. The line may or may not have an arrow to show dependency of the activities. The line frequently has the name of the activity and the planned duration in days or weeks. The events are identified and numbered, with the latter information to show the sequence or order of the events. Variations on these may also include resource estimates, mandays or manmonths, or dollars. Exhibit 6-8 is an example of a simple arc and node network.

The other major form for graphically depicting the network is shown in Exhibit 6-9. In this type of network all of the information is provided within the box, and the lines only serve to connect the boxes. Dependency relationships are indicated by the position of the boxes in relation to one another. As can be seen in this example a lot of different information can be



Source: Feiler, A.M., Project Management Through Simulation, Project TRANSIM, Department of Engineering Systems, UCLS, December 1976

Exhibit 6-8. EXAMPLE OF ARC AND NODE NETWORK



Source: Computer Supported Network Analysis System (CSNAS), operated by AFALC/XRI

Exhibit 6-9. EXAMPLE OF GRAPHIC NETWORK ILLUSTRATION

provided. Each box represents an activity/event group. The dates on the top are one set of target start and end dates, such as for early start and completion or the optimistic plan. The dates on the bottom of the box are for a less optimistic plan. The information inside the box includes the name of the activity/event, and the identification/sequence number. The slashed number in the lower left represents the task duration (weeks/days), while the percentage of the task completed is in the lower right. Slashes through the box indicate tasks completed. While not all automated network analysis systems may depict this information in this way, it is desirable to collect and maintain the data.

A third characteristic of networks is that they allow forecasting of the impact of different conditions on the total schedule. Changes in completion date or resource utilization can be incorporated in the network and the effects of these changes can be projected. Neither Gantt Charts nor milestone schedules can be used in this way, largely because of their inability to depict dependency relationships. PERT requires estimates of low, most likely and high resource requirements, which are used in employing the forecasting aspect of the technique.

A fourth characteristic of networks is their ability to represent the activities/events on the critical path. These are the tasks which determine the total duration of the schedule, and in which there can be no slack time (differences between early and late start and completion dates). The critical path is usually the focus of management concern because schedule slippage

of tasks on the critical path will produce a similar slippage in the final milestone, assuming all else stays the same. Network analysis allows for the identification of the tasks on the critical path. Since these may frequently not be the tasks which would have been considered the most "important" it is vital to know and understand their impact on the ultimate goal. It is also important to understand that as the effort progresses the composition of the critical path can change, with tasks moving off and on the path.5/ Guidance on the development of a schedule network is provided in Appendix E.

As noted earlier, one of the most frequently used network analysis techniques is PERT. Since its original introduction with the Navy's POLARIS program in 1958, PERT has fallen in and out of favor as a scheduling and analysis technique. A variation of PERT/CPM is currently available for ILS planning through AFALC/XRI. This system, the Computer Supported Network Analysis System (CSNAS), is currently used by a number of major SPOs including the B-1B, F-16 FMS, LANTIRN, B-52 Deployment Office, and many others. PERT is defined as:

> "A deterministic networking technique which uses a time-oriented critical path analysis to aid in the planning and controlling functions of management. Deterministic, in this sense, refers to the fact that an event following an activity cannot be considered accomplished until all activities leading to the event are completed, and all activities starting at an event will occur. The time estimates may be either single or three time estimates. The word "PERT" infers PERT TIME; it does not include PERT COST. [PERT COST is] a PERT network on which both schedule and costs are planned and controlled on a common framework."6/

5/ A more detailed generic discussion of network analysis is contained in the Program Scheduling Handbook, ESD/ACBB. Additional sources are also listed in Appendix A.

6/ Ewart and Nanney, An Analysis of PERT in Weapon System Acquisition.

The major distinction between PERT and CPM is the more statistical orientation of PERT; however, generally these terms are used jointly in referring to the major network analysis techniques. In the study Project Management Through Simulation,[7/] the pros and cons of using deterministic network analysis versus more complex simulation techniques which incorporate potential uncertainty through the use of probability, are discussed. While many other studies are available which consider applications of these techniques, this study considers aspects of particular pertinence in light of the goals of this handbook. The following discussion has been extracted from the study.

SHORTCOMING OF CRITICAL PATH TECHNIQUES

"Although experienced project managers recognize many of the project uncertainties they face, their ability to cope with uncertainty-related problems is limited because of the shortcomings of analytical techniques. The basic problem is that conventional critical-path techniques such as PERT, CPM, and other similar techniques which are now receiving widespread use for planning, scheduling, resource analysis, and costing -- are all "deterministic." That is, they depend upon single-value data inputs to the network plan and analysis and therefore, cannot account for the many uncertainties which are inherent to real-life project performance. The inability to account for uncertainty makes it difficult to identify and deal with the complex interactions that can develop among the project activities. Unfortunately, such interactions can profoundly affect overall project performance. They invariably add to project duration and increase its cost and they rarely improve project performance.

"The magnitude of the optimistic bias of deterministic network analysis results is determined by a number of factors:

1. The particular project activity network configuration:

    a. the length (time-duration) of the longest time path relative to the other paths

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7/ Fieler, A. M., Project Management Through Simulation, Project TRANSIM, Department of Engineering Systems, UCLA, December 1976.

b. the number of near-critical paths, i.e. very close in time duration to the critical path

c. the number of common nodes among the paths which have some level of criticality

d. the number of activities which have less than 100 percent probability of occurring.

2. The degree of variability of task performance of activities on the critical path and on near-critical paths.

3. Allocation of scarce resources based on deterministically-determined resource requirements.

"One of the more misleading aspects of conventional deterministic methods is the assumption that there is a unique "critical" path (longest time path) in a project network. Where individual project activity performances are variable, there are usually several paths which could prove to be longest, depending upon the eventual realization of activity times. The probability that an individual activity will lie on the longest time path for a specific network realization is a measure of the activity's "criticality."* Accordingly, the activities requiring close managerial attention are those with significant criticality - it should not be limited to those on the single critical path of deterministic techniques. In a typical project, as many as 50 to 60 percent of the project activities can have a significant level of criticality."

It is useful at this point to recognize that PERT and the other members of the class of more sophisticated networking techniques have multiple roles in program management and control. They not only fulfill the function of depicting the activities, events, time and relationships involved in accomplishing the program. They also can be used as more dynamic management tools in the area of program control. In this respect they are used to develop and evaluate alternatives and to forecast impacts of changes in the schedule or resource allocation plan, and to

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*"Activity 'criticality' may be viewed as a direct measure of the activity's sensitivity, i.e., its importance to overall project performance. Criticality is measured in percent between zero and 100; the higher the percent criticality, the more the activity's impact on overall project performance."

evaluate risk. In the latter capacity particular techniques are discussed in Chapter 10.

The following discussion of the general strengths and weaknesses of network analysis techniques has been adapted from the Program Scheduling Handbook referenced above.

1. Strengths

"Network schedules give us the logic and organizational structure to combine many activities and incorporate the complexity of the relationships between tasks. This lets us gather schedule information from all available sources within a program and then integrate that data in a graphical form that clearly shows what we know about the way the program will be executed. At the same time the process of building the network will highlight what we don't know and give us the chance to fill in the gaps where possible.

"A network is ideal for the planning phases of a program when there is still some flexibility in the time-phasing of activities. A good network analysis of a program sets a firm foundation for getting things moving in an orderly fashion when the go-ahead is received for a project. If this initial effort is tied in with an organizing scheme...products from the network schedule can be extracted either by responsible organization or the WBS items. We can thus provide sub-schedules for the effort that a program participant must accomplish over a period of time (this could be a simple milestone chart or a network in itself). These products are well suited to documents such as the Program Management Plan (PMP). AFR 800-2 states that the PMP is directive on program participants!

"A network schedule can be developed at any level of detail and the more detail we can incorporate the greater the accuracy of the schedule predictions. No one will argue much with a very generlized schedule of the program, but as soon as we start showing the level of detail that explicitly defines the interactions between groups for specific tasks there will be plenty of feedback. Some of the exchanges may be emotional as an individual feels his area of responsibility is being encroached, but they will be exchanges of information. That is the objective in the first place!

"Network analysis can be used at any phase during a program's life cycle, but the objective and the use of results will vary. An analysis performed during the Full Scale Engineering Development phase may indicate that we have a low confidence of meeting the directed date for an Initial Operational Capability

(IOC). That may be a very unpopular result, since most program parameters are already set (especially the budgets). But this type of analysis can give ideas of where to concentrate on improving schedule performance. It may also show us that current plans cannot be accomplished and should be changed!

2. Weaknesses

"There have been strong arguments voiced against the use of large network schedules as a management control technique. These criticisms have centered on the PERT and CPM approaches, but apply to networking in general. Once an effort is underway a large network can become unwieldy to maintain as plans inevitably change. PERT-type efforts to control entire programs or contracts within a program can collapse of their own weight. The result may be a monthly report that is simply a minor rehash of the initial plan and not descriptive of the current situation. With networks, bigger is rarely better.

"A network is an approach for setting up a management information system. There are other ways of fulfilling the information needs of project management (i.e., planning, organizing, directing, and controlling), but no approach will work unless we properly scope the amount of effort needed to support it and make a conscious decision to commit those resources. A network-based system can require a relatively large amount of time to set up and maintain, although the degree of the application can be tailored by the level of detail incorporated (and that is [the] suggested approach).

"If there is not a clear commitment by upper level management (SPO Director and Division Chiefs) to implement and use a network system it will not be a medium of information exchange. The management style of an organization is chosen by the boss, either explicitly or implicitly. It soon becomes obvious to the members of an organization what informtion the boss thinks is important and this is where the real effort is focused.

"Computer based network systems are the next area of problems. Large network applications are normally automated to some extent since the amount of data being maintained is extensive. Most contractor developed schedules are some form of automated network. Although there are efforts in process to provide this type of computer support to our program offices, the access to these resources is limited at this point, so we have a very limited ability to handle large-scale networks internally.

"The PERT and CPM systems have also been criticized for their tendency to focus attention on the critical path only.... There can be a considerable amount of "optimistic bias" in the expected time predicted by the single critical path calculations. We can get a general idea of the extent of the problem for any application by identifying the number of alternate paths through the network that are close in total length to the critical path

(say within a few %). The slack time will be low on these paths. If there are multiple paths close to the critical path length, then the expected time will be optimistic to some extent and a more complex method should be used."

As can be seen from these and the preceeding evaluation of network analysis techniques, it is important to select an appropriate level of detail with which to represent the program activities, and to take precautions against embedding overly optimistic estimates of future accomplishments.

CHAPTER 7. STRUCTURE OF CONCURRENCY SCHEDULE ANALYSIS

- Program Schedule Components
- Overview of the Analysis
- Description of the Analytical Process

CHAPTER 7. STRUCTURE OF CONCURRENCY SCHEDULE ANALYSIS

Given that a Program Manager has selected a scheduling technique appropriate for the character of his program, he must also be able to analyze the impacts of applying concurrency. Concurrency can be used in a number of different ways in a program, as discussed in Chapter 2. Three types of concurrency have been identified:

- <u>normal concurrency</u>, used as a scheduling strategy for balancing workload and personnel assignments;
- <u>planned concurrency</u>, used as an acquisition strategy for allowing an early IOC or for reducing risk; and
- <u>exceptional concurrency</u>, used as a management strategy to compensate for unforeseen problems or to respond to a crisis.

Regardless of the type of circumstances surrounding the application of concurrency, it is necessary for the Program Manager, or more likely the Program Control Directorate, to evaluate the risks of concurrently scheduling certain activities. This will usually involve the Program Control Directorate, or the specific functional area, developing a preliminary schedule of the segment of the program involved and then performing a series of simulations or "what if" exercises to estimate potential impacts.

This chapter lays out a structured approach for analyzing these impacts with the goal of producing a revised schedule.[1/]

1/ The concurrency analysis structure described in this chapter has been adapted from the following report. Ingley, Patricia A., et al, <u>Shortening the Acquisition Cycle: Research on Concurrency</u>, TR-8124-1, Management Consulting & Research, Inc., Falls Church, Virginia, 30 September 1982.

PROGRAM SCHEDULE COMPONENTS

In attempting to understand what concurrency involves, specific factors and criteria must be developed for considering project activities and decisions required of the Program Manager. The basic components in creating program schedules must be identified. The program activities and events can be considered in light of these components.

Specifically, it is necessary to consider:

- Phases - acquisition phases such as Concept Exploration, Demonstration and Validation, Full Scale Development, and Production;
- Functions - major categories of work performed in, or under the direction of, the Program Office such as Technical Management, Logistics Management, Business Management, etc.;
- Task Areas - subtasks of functional work such as hardware design, software design, test and evaluation, etc., under Technical or Systems Management;
- Events - end points such as document delivery, design review meetings, milestones, and initiation of development of documents;
- Activities - efforts involved in preparing for a particular event, or following a starting event, such as preparation of a baseline and review of a procurement plan; and
- Organizations - groups responsible for performing activities such as the Program Office functional groups or contractors.

These must be presented in terms of time in order to produce a schedule.

In addition to these basic components, a program schedule is individualized based on two other considerations:

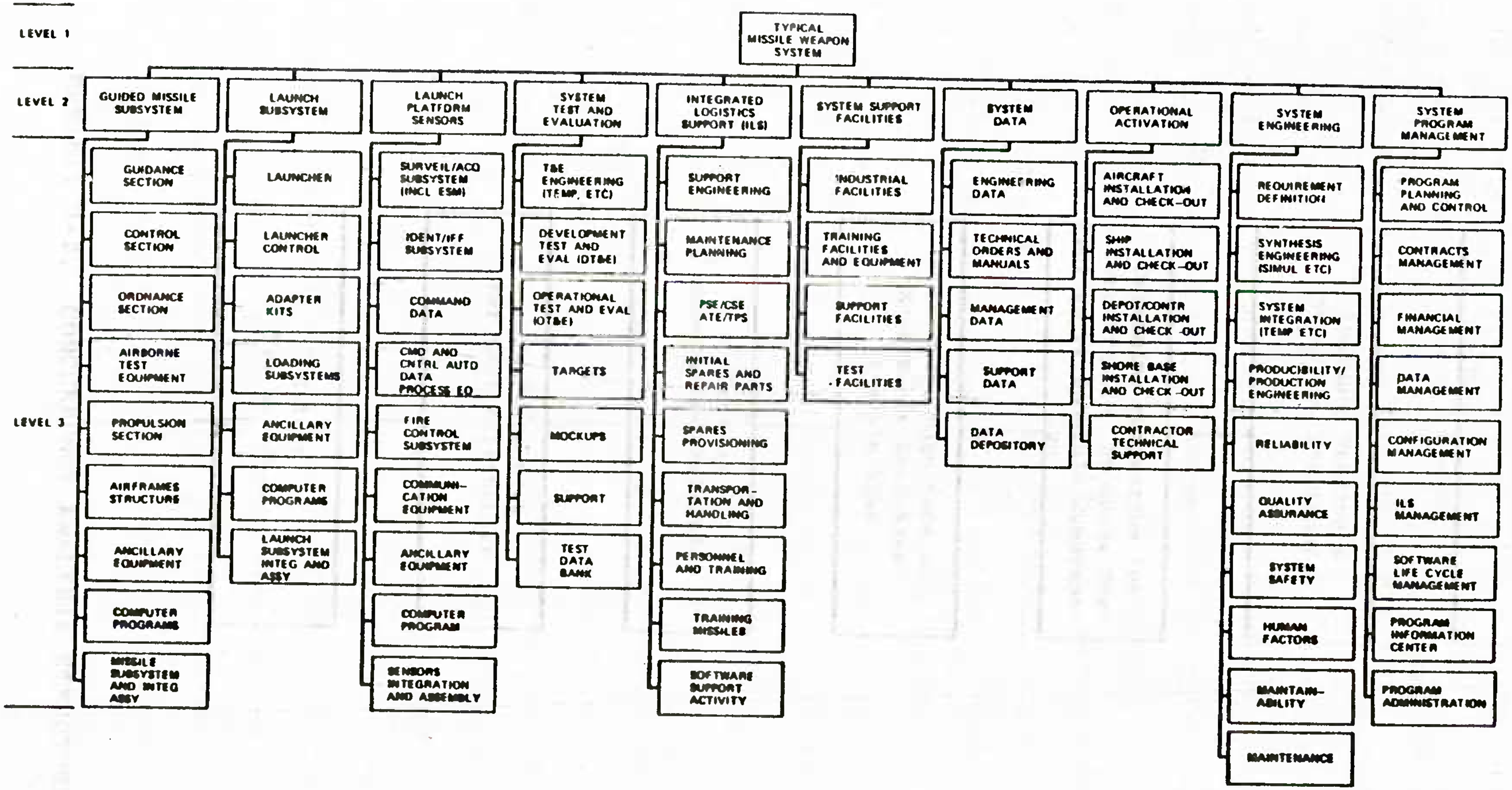
- System Type - generic type of weapon system related to the program schedule, e.g., aircraft, missile.
- Subsystems - level two work breakdown structure elements of hardware, as defined by MIL-STD 881A, which may be on different developmental schedules, but which collectively constitute a viable weapon system.

Exhibit 7-1 illustrates an example of a work breakdown structure. Schedules must be developed for work in each of the three levels, with the Level 1 schedule corresponding to the master program schedule. Level 3 schedules are aggregated in an integrated summary schedule for the Level 2 subsystem.

In examining the degree of desirable concurrency for a particular program many factors must be considered. The following considerations are briefly summarized here:

- factors influencing the applicability of concurrency,
- acquisition cycle-related problems,
- previously suggested alternatives,
- pros and cons of increased concurrency, and
- factors for changing program concurrency.

It is not clear that concurrency is applicable to all system acquisitions. Development factors such as design status, familiarity of technology, environmental characteristics, program office personnel experience, and contractor availability/experience; and production factors such as production resource availability/manufacturing capability, and level of previous program involvement are all important. But so, too, is the discipline required (risk management) of scheduling far in advance of an actual requirement (i.e., consider production and logistics



Source: Navy Program Manager's Guide, P-9494, Naval Material Command, July 1983

Exhibit 7-1. THREE-LEVEL WORK BREAKDOWN STRUCTURE

problems very early in the cycle). Risks of technological advancement or lack of maturity of design balanced against high development cost or high cost uncertainty can doom a program and require higher costs of maintaining low-risk alternatives. There is a complex hierarchy of responsibility and review that also contributes to the problem rather than to the solution. In addition to these needs the program schedule must also be analyzed in terms of its sensitivity to external forces such as political and budgetary decisions.

OVERVIEW OF THE ANALYSIS

The approach taken in developing an analytical structure for the PM to use in making concurrency-related decisions has been to construct a logical framework for utilizing a progressive accumulation and refinement of data. The analysis is structured to be neither weapon system specific, nor sensitive to a particular level of detail. Rather, it is applicable to any system, with appropriate tailoring, and any level of organizational detail.

Exhibit 7-2 shows the structure of this analysis. This structure is composed of seven basic steps to be performed by, or under the direction of, the Program Manager. The first step involves the development of the initial program schedule which forms the basis for concurrency and cost/schedule/readiness risk analysis. It also includes the formulation of the rules and criteria for performing the analyses, and the identification of an initial set of concurrency options.

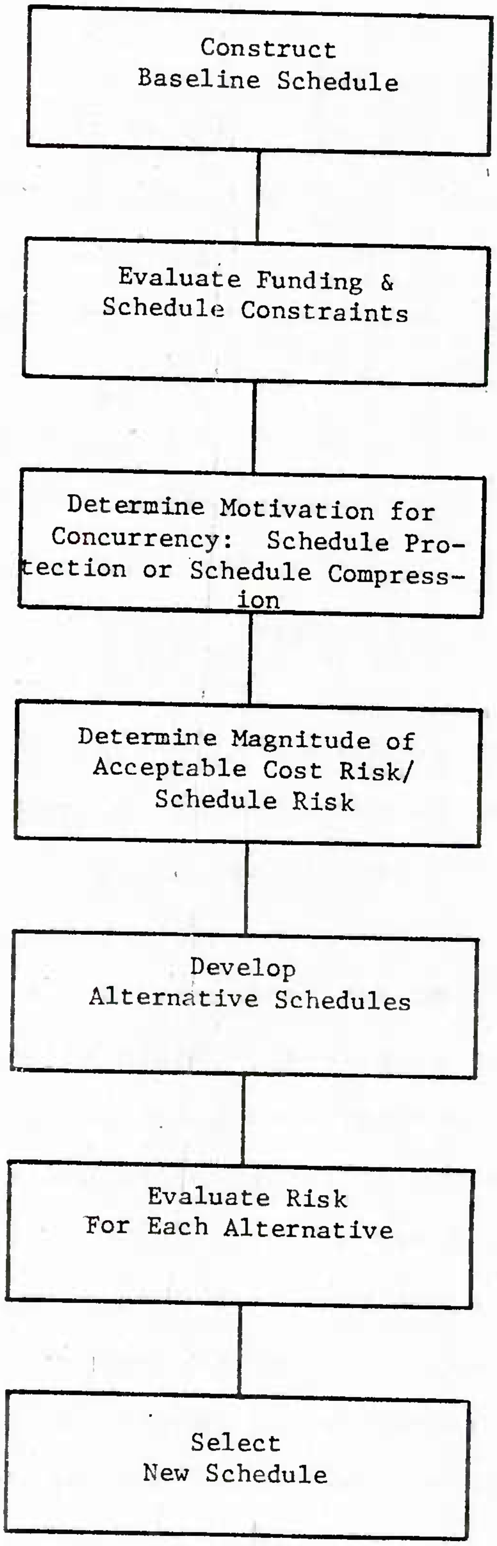


Exhibit 7-2. CONCURRENCY ANALYSIS STRUCTURE

Having set up the problem, the second step concerns the considerations of the constraints to which the PM must respond in the schedule. These constraints may be pre-existing or newly imposed, endogenous or exogenous to the program. This step is closely related to the third step, determining the reason for considering concurrency. In evaluating the constraints the PM must determine the desirable scope of the concurrency, i.e., the phases, functions, task areas, and activities affected by the implementation of concurrency. In recognizing the motivation, the PM is also considering the ultimate purpose to be achieved by using concurrency as a scheduling mechanism, as well as the circumstances driving the decision, i.e., earlier schedule slippage, protection of the remaining schedule, incorporation of changing direction, etc.

In the fourth step, the PM determines the magnitude of acceptable risk to be considered in developing and selecting alternatives. This narrows down the set of possible alternative schedules which could fulfill the requirements. It is at this point that decisions are made about acceptable degrees of concurrency and risk. Based on the analysis performed in the previous steps, it is possible that there may be more than one set of concurrent activities in an alternative, each of which will have to be decided upon.

The fifth step involves the development of alternative schedules which are within the scope of the preceeding constraints and risks. A variety of alternatives, addressing one or more of the previously selected sets of concurrency options, may be developed.

The companion to this step is the analysis of the risks associated with each alternative, performed in the sixth step. The evaluation of the alternatives is performed using checklists tailored to the particular characteristics of the system type, the stage in the development of the system, and the particular task areas and activities involved. Development of these structured checklists is begun with the selection of the concurrency options in step one and is continued through each step, incorporating the refined direction that is being developed in this process. They are tailored to respond to the information the PM needs to make an actual decision.

Having evaluated and scored the alternative scheduling options, the final step is the selection of the alternative which most adequately satisfies the requirements at the time of the decision. Using the basic criteria developed in the first step, and refined for the actual decision, the PM trades-off the options presented in the alternatives among cost, schedule, readiness, and risk in the program environment. The ultimate selection is the revised schedule. Although a single alternative may be selected in this process, it is often the case that other viable alternatives have been developed and should be monitored in the process of subsequent schedule reviews.

Initially, several assumptions are made:

- the Program Manager is assumed to have a Baseline Schedule;
- funding and schedule constraints can be defined;
- resource estimates (e.g., of time, cost and manpower levels) can be made for each schedule component;

- analysis of alternative schedules representing relatively fixed performance will be performed; and
- concurrency can be meaningfully considered in terms of potential savings in time versus risk.

The Top Level Hypotheses (TLH) are simply that:

- program schedules can be quantitatively and qualitatively evaluated;
- quantitative or qualitative risk analysis measures can be developed and applied to evaluate degrees of project concurrency; and
- the Program Manager can himself make meaningful decisions regarding shortening the program acquisition cycle using a structured checklist methodology.

Given these hypotheses, the PM must be able to intelligently apply available analytical techniques to his program in order to make concurrency decisions.

DESCRIPTION OF THE ANALYTICAL PROCESS

The following is a brief description of the analytical process represented by the steps listed in Exhibit 7-3.

Step 1: Construct Baseline Schedule

Purpose: Construct foundation for making decisions on program schedules by performing initial analysis.

Approach:

1.1 Develop program schedule philosophy (PSP)
1.2 Construct baseline network
1.3 Identify potential concurrency options
1.4 Develop structure of risk evaluation checklists

The first step in addressing the problem of concurrency is to identify the specific characteristics of the program which must be identified in order to make decisions on adjustments to the

Step 1. Construct Baseline Schedule
- 1.1 Develop Program Schedule Philosophy
- 1.2 Construct Baseline Network
- 1.3 Identify Potential Concurrency Options
- 1.4 Develop Structure of Risk Evaluation Checklists

Step 2. Evaluate Funding and Schedule Constraints
- 2.1 Determine Significance of Constraints
- 2.2 Determine Scope of Concurrency
- 2.3 Relate Constraints to Concurrency Options

Step 3. Determine Motivation of Concurrency: Schedule Protection or Schedule Compression
- 3.1 Determine Extent of Internal Program Limitations
- 3.2 Refine Baseline Schedule Estimates
- 3.3 Reevaluate Preceeding Decisions
- 3.4 Develop Initial Set of Risk Evaluation Checklists

Step 4. Determine Magnitude of Acceptable Cost Risk/Schedule Risk
- 4.1 Develop Final Baseline Resource and Schedule Estimates
- 4.2 Determine Acceptable Degree of Concurrency
- 4.3 Determine Acceptable Degree of Risk
- 4.4 Review Remaining Concurrency Options

Step 5. Develop Alternative Schedules
- 5.1 Select Constrained Concurrency Options to be Used in Developing Alternatives
- 5.2 Group Concurrency Options for Development of Alternatives
- 5.3 Generate Alternative Schedules
- 5.4 Determine Critical Path for Each Alternative

Step 6. Evaluate Risk for Each Alternative
- 6.1 Finalize Evaluation Checklists
- 6.2 Apply Checklists to Detailed Schedule and Subschedules
- 6.3 Score Each Alternative Based on Cost and Schedule Risk and Response to Constraints
- 6.4 Aggregate Data to Decision-Making Level of Detail

Step 7. Select New Schedule
- 7.1 Review and Revise Decision-Making Criteria
- 7.2 Review and Revise Proposed Schedule-Monitoring Techniques
- 7.3 Analyze Results of Risk Analysis of Alternatives
- 7.4 Apply Decision-Making Criteria to Viable Alternatives
- 7.5 Select Alternative
- 7.6 Revise Existing Schedule

Exhibit 7-3. STEPS IN CONCURRENCY ANALYSIS

schedule. Developing the program schedule philosophy involves construction of the policy and procedures or rules for organizing the analysis, and construction of the criteria for making scheduling adjustment decisions. It also includes determination of the level of specificity of the on-going analysis, a reevaluation schedule for the program schedule throughout the acquisition, and a description of basic information requirements necessary for the analysis. This philosophy is subject to refinement, as is the schedule.

After developing the basic rules for considering the program schedule, the next substep is the actual identification of the activities and events to be scheduled, the development of projected values for each; the identification of the tasks and subtasks which compose each activity; and, finally, the arranging of this information in a set of networks, reflecting various levels of detail.

The third substep in constructing the schedule foundation is the identification of concurrency options. Not all of the activities and events in a program schedule can be concurrently scheduled. Therefore, it is vital to identify for each schedule (the initial as well as subsequent revisions) those activities and events which <u>cannot</u> be reordered or adjusted. Although initially identified when the program schedule is constructed, the concurrency options must be reevaluated as portions of the schedule are completed.

The final substep in the initial organization of the analysis is the development of the basic structure of the risk

evaluation checklists. These checklists will be used in Step 6 to evaluate the alternatives.

Step 2: Evaluate Funding and Schedule Constraints

Purpose: To determine the potential scope of the concurrency requirements, based on specific funding, readiness, and schedule constraints.

Approach:

2.1 Determine significance of constraints
2.2 Determine scope of concurrency
2.3 Relate constraints to concurrency options

In this step the actual analysis of concurrency potentials is begun. The first step primarily concerns the development and organization of information in a manner useful to further analysis. This second step, evaluation of constraints, involves the further refinement of direction through a three-step process.

A basic assumption underlying this analytical process is that schedules should and must be re-evaluated because they incorporate an approach which may no longer be appropriate. Schedule inappropriateness may be due to a variety of reasons (more specifically considered in Step 3). However, it can be translated into constraints which reflect changes in resource requirements or demands. These constraints may be due to circumstances within the program or outside it. They may take the form of restrictions on:

- the amount of time remaining to accomplish an activity in any of the schedule levels,
- the projected cost allowed to complete development,
- availability of organizations to perform the work, or
- the projected level of risk.

The characteristics of the constraints will, in turn, influence the potential scope of the concurrency. The scope relates to how extensive the concurrency may be, spannning phases, functions, task areas, activities or organizations. Less significant constraints may allow for restricting the scope of the concurrency to a few activities at the sub-schedule level. The more significant the constraints, in terms of total program resources, the more extensive the scope of the concurrency. The scope is tentatively determined in this sub-step and refined, if necessary, as the analysis progresses.

The final substep in Step 2 involves relating the constraints to the concurrency options (identified in the first step) within the tentative scope of the concurrency determined above. Many of the original concurrency options previously identified will be eliminated, since they are outside the scope of the projected concurrency requirements.

Step 3: Determine Motivation for Concurrency: Schedule Protection or Schedule Compression

Purpose: Determine the amount of flexibility and limitations existing within the program relating to alternatives open to the PM.

Approach:

3.1 Determine extent of internal program limitations
3.2 Refine schedule uncertainty and dependency estimates
3.3 Reevaluate previous decisions
3.4 Develop initial set of risk evaluation checklists

This step is iteratively related to the preceeding step. In this step peculiar characteristics and conditions within the program are considered. Particular consideration is given to how

they may influence or further constrain the potential options for developing alternative schedules. There are four substeps in this part of the analysis. The first three substeps are performed and, if necessary as a result of these analyses, the decisions made in Steps 1 and 2 are revised to take into account these additional constraints.

The first substep is directed toward identifying specific constraints which are known to exist within the program. Some of these constraints may prohibit rescheduling or reordering of activities and events which would otherwise be viable concurrency options. There are a variety of conditions which could produce this effect including already slipped schedules, previously completed activities, or activities already in progress which cannot be redirected or rescheduled. This analysis will reveal the general orientation of the planning toward schedule protection or schedule compression.

In the second substep the preliminary estimates on the degree of uncertainty and the dependency of activities and events are reevaluated and refined, if necessary, to reflect the additional understanding of the program constraints. Related to this is the third substep in which previously made decisions on concurrency options and the checklist structure are reevaluated and modified, if necessary. Finally, an initial set of checklists is developed as a result of this analysis. These checklists are tailored to address the cost risk and schedule risk associated with the options used to generate the alternatives.

Step 4: Determine Magnitude of Acceptable Cost Risk/ Schedule Risk

Purpose: Finalize draft decision-making criteria and parameters for selecting alternate schedules.

Approach:

4.1 Develop final baseline resource and schedule estimates
4.2 Determine acceptable degree of concurrency
4.3 Determine acceptable degree of risk
4.4 Review remaining concurrency options

In this step the basis for developing the schedule alternatives are further refined and additional detail is developed. In the first substep the estimated resource requirements for accomplishing the remainder of the program schedule are reviewed and final modifications are made. These estimates are for the cost, time and manloading required for each activity and event in the detailed schedule.

Based on these estimates, the degree of concurrency deemed to be acceptable is determined in the second substep. The degree of concurrency is based on the amount of overlap a dependent or successor activity has with its predecessor activities. The degree of concurrency acceptable to the PM will influence the amount of risk associated with a particular concurrency option. In determining the acceptable degree of concurrency the PM can decide an overall amount for the program, such as "no more than 10%", as well as acceptable amounts for each concurrency option, based on the perceived risks associated with each.

In addition to determining the acceptable degree of concurrency or amount of overlap among activities, it is also necessary

to determine the limits of the risks the PM is willing to tolerate in shortening the acquisition cycle. Of particular interest are cost risk, readiness risk and schedule risk, and the relationship between the three. In this substep the PM makes a preliminary determination of the limits of risk and the circumstances under which additional risk will be undertaken.

The last substep is the final review of the remaining concurrency options. Given the preceeding analysis, it is possible that some of the initial concurrency options may be eliminated or further constrained. It is important to determine that before proceeding further in the development of alternative schedules, since those constrained options form the basis for constructing the alternatives.

<u>Step 5: Develop Alternative Schedules</u>

Purpose: Translate sets of concurrency options into actual scheduling alternatives capable of being evaluated in terms of cost and schedule risk.

Approach:

5.1 Identify constrained concurrency options to be used in developing alternatives
5.2 Group concurrency options for development of alternatives
5.3 Generate Alternative Schedules
5.4 Determine Critical Path for each alternative

In this step the actual alternative schedule or revisions to the baseline schedule are developed and prepared for further analysis. In order to do this the first substep involves determining which of the remaining concurrency options will be used as the basis for generating alternatives. It is conceivable that not all of the options will be applicable and an effort should be

made to identify those that are not. The potentially large resources required to generate alternate schedules make that identification worthwhile.

Having identified which options will be used, the next substep involves arraying the options in alternative groupings. It is possible to generate a variety of alternatives by varying the combination of concurrency options and the projected values and schedule for each. It is at this point that the PM has the greatest opportunity to be innovative, examining the specific needs of each option and determining the minimum requirements to begin each activity. These innovative approaches are considered in the context of the acceptable amount or degree of concurrency and risk determined in Step 4.

Having developed the base for each alternative, the actual alternative schedules can now be generated. As part of this process it is worthwhile to review the preceeding analysis to insure that all of the internal and external constraints, as well as previously developed direction, are accounted for in the alternative schedules.

The final substep in this portion of the process is the determination of the critical path in each of the alternatives. It is possible at this point that some of the alternatives could be eliminated from further consideration due to the construction of the critical path.

<u>Step 6: Evalute Risk for Each Alternative</u>

Purpose: Analyze alternative schedules as approaches for responding to constraints.

Approach:

6.1 Finalize risk evaluation checklists
6.2 Apply checklists to detailed schedules
6.3 Score each alternative based on cost and schedule risk, and response to constraints
6.4 Aggregate data to decision-making level of detail

In this step the alternative schedules generated in Step 5 are evaluated to determine their appropriateness as approaches to dealing with the new constraints. The major mechanism for doing this is a set of evaluation checklists, tailored to particular phases, functions, task areas and activities of interest in the particular analysis. The first sub-step in this evaluation is finalizing the checklists initially developed in Step 3. The final version of the checklists should be tailored to address the particular activities and events which have been manipulated in the alternative schedule. They must be designed to produce a risk value, e.g., High, Moderate, Low, for each consideration. Since the schedules are generated at multiple levels of detail, the checklists must address those same levels. The checklists are now reviewed to ensure their consistency with the decision-making criteria originally developed in the PSP (Step 1).

After finalizing the evaluating checklists, they will be used to review each concurrency alternative. These checklists will be structured to address the activities and events rescheduled in the alternatives. However, in applying them, the values and degree of concurrency and risk determined for each option or group of activities must also be considered.

In the third substep, the projected cost, readiness, and schedule risks associated with each alternative are quantified.

The result of this analysis is a ranking according to cost, readiness of, and schedule risk of the alternative schedules. This ranking reflects the results of applying the checklists to each alternative, in light of the following considerations:

- degree of concurrency,
- total risk calculated and the peak risk estimated,
- amount of uncertainty associated with the resource and schedule estimates,
- dependency relationship among activities and events,
- overall influence of activity in program schedule and cost,
- stage of system technology development, and
- perceived scope of impact of decision/consequences of failure of schedule or cost projections.

Specific attention must be given to determining the risks of exceeding the:

- total costs if the concurrently scheduled activity fails to succeed,
- total schedule if the concurrently scheduled activity fails to succeed, and
- projected activity cost or schedule estimate.

The final substep in the risk evaluation portion of the analysis involves aggregating the risk values to the predetermined decision-making level of detail. Depending on the circumstances this may occur at the Summary, Detailed or Sub-schedule level.

<u>Step 7: Select New Schedule</u>

Purpose: To make decisions on schedule revisions based on analyzing risks associated with the alternatives.

Approach:

7.1 Review and revise decision-making criteria in PSP
7.2 Review and revise proposed schedule-monitoring techniques
7.3 Analyze results of risk analysis of alternatives
7.4 Apply decision-making criteria to viable alternatives
7.5 Select alternative
7.6 Revise existing schedule

The final step in this analysis involves making decisions on the alternative schedules. In the preceeding steps preliminary decisions would have been made on how to decide which of the alternatives will be selected and how to evaluate the effectiveness of the revised schedule. The first substep in this final part of the analysis is to review and revise, if necessary, the decision criteria contained in the PSP. In the process of identifying and reviewing the concurrency options, and developing and evaluating the alternative schedules, it is quite possible that additional imperatives contributing to the decision-making process will be identified. The criteria should be modified to incorporate those additional considerations.

In addition to reviewing the decision-making criteria it is, at this point, also useful to review the originally proposed techniques for monitoring the revised schedule and the potential alternatives. In the set of alternative schedules some will be eliminated for future consideration simply by the choice of a particular alternative. However, some alternatives may not be totally eliminated as possibilities since their divergence from the revised schedule occurs later in the program. These alternatives should be monitored as the schedule progresses to allow their maintenance as scheduling options.

The third substep involves analysis of the results of the risk analyses, performed in Step 6. The risk values developed for each alternative are arrayed on a graph illustrating their comparative cost and schedule risk values. Additional illustrations such as cost and schedule contours are also developed as part of this substep.

The fourth substep involves evaluating each of the risk-assessed alternatives in terms of the decision-making criteria. If constructed adequately, these criteria represent the significant points of concern and priorities of the PM. Each alternative is given a ranking based on the risk assessment and application of the decision-making criteria.

The fifth substep is the actual selection of the alternative or revised schedule, and the secondary alternatives which will be monitored.

The final substep in this process is the initiation of the revised schedule and incorporation of it into the program plan.

CHAPTER 8. ANALYSIS OF CONCURRENCY SCHEDULE RISK

- The Role of Risk Analysis in Acquisition Planning
- Concurrency Application Considerations
- Evaluation of Risks

CHAPTER 8. ANALYSIS OF CONCURRENCY SCHEDULE RISK

In the preceeding chapter, a structured approach for analyzing concurrency impacts and revising schedules was described. Part of this analysis involves developing risk targets and calculating estimates of risk. In this chapter, potential applications of this risk analysis are discussed. (Detailed discussions of the elements of risk analysis and actual techniques for performing risk analysis are discussed in Part IV of this handbook, Chapters 9 and 10.)

THE ROLE OF RISK ANALYSIS IN ACQUISITION PLANNING

Risk analysis should have an important place in the planning and execution of any complex program. The importance that must be placed on the performance of risk analysis is enhanced when concurrency is adopted as an acquisition or management strategy. The principal reason for this is that the ensuing compression of the acquisition process as a result of concurrent scheduling amplifies the negative impacts of factors that introduce risk and uncertainty into program planning. These factors include:

- technical problems that may introduce delays in the program that can only be rectified at increased cost or sacrifice of performance (system readiness);
- pressure applied by organizations outside the Program Office where decisions made for political reasons may have a significant impact on the program;
- assumptions made about economic conditions, particularly forecasts such as those of inflation rates, that impact program cost estimates;

- changes in the requirements statement as a result of reassessment of the threat or changes in the operational environment of the system being acquired; and

- changes in the acquisition strategy that may result from changes in program budget, changes in the production schedule, or changes to the planned maintenance and support philosophies for the system.

In considering the use of concurrency as a scheduling option, it is important to be able to analyze the risks associated with that implementation as well as with alternative scheduling options. In this regard, development factors such as design status, familiarity of technology, environmental characterisitics, project personnel experience, contractor availability/experience, and production factors such as production resource availability/manufacturing capability, and level of previous program involvement are all important. But so, too, is the discipline required to schedule far in advance of actual requirements, e.g., to consider production and logistics problems very early in the cycle. There is a complex hierarchy of responsibility and review that also contributes to the problem rather than to the solution. In addition to these needs, the program schedule must also be analyzed in terms of its sensitivity to external forces such as political and budgetary decisions.

In assessing the impacts of concurrent scheduling, the Program Office must:

- identify the risks that are introduced,
- determine what advanced planning is necessary,
- decide on the precedence relationships that exist among the various projects and tasks to be performed,

- locate the critical path in any schedule that is produced,
- locate the "choke points" in the schedule, and
- identify those portions of the schedule that will take a fixed amount of time or dollar resources regardless of the level of effort applied to them.

These are just some of the particular aspects of planning for concurrency that must be considered. Others are identified throughout this handbook.

The last item listed above is an important one since it is often overlooked in planning. As an example of planning considerations that must be made in this area, it is instructive to discuss the development of avionics software. Exhibit 8-1 illustrates the general time span for avionics software development. Among the precedence relationships that occur in program planning, is one that comes about due to the fact that avionics software development cannot be started until system requirements are known. Usually this has not been before FSD (Full-Scale Development). The first operational flight program usually takes from 36 to 42 months to develop, unless nuclear certification is required, in which case 12 months must be added to the planning time.[1/]

The reason that avionics development time is relatively fixed, is that it is a people-intensive, very sequential activity. And as with most software development programs, adding more coders would not shorten the development time and may only add inefficiency. That is coupled with the fact that upfront,

1/ These estimates are based on the experience of the Avionics Control Branch (ASD/AX) in developing avionics systems software.

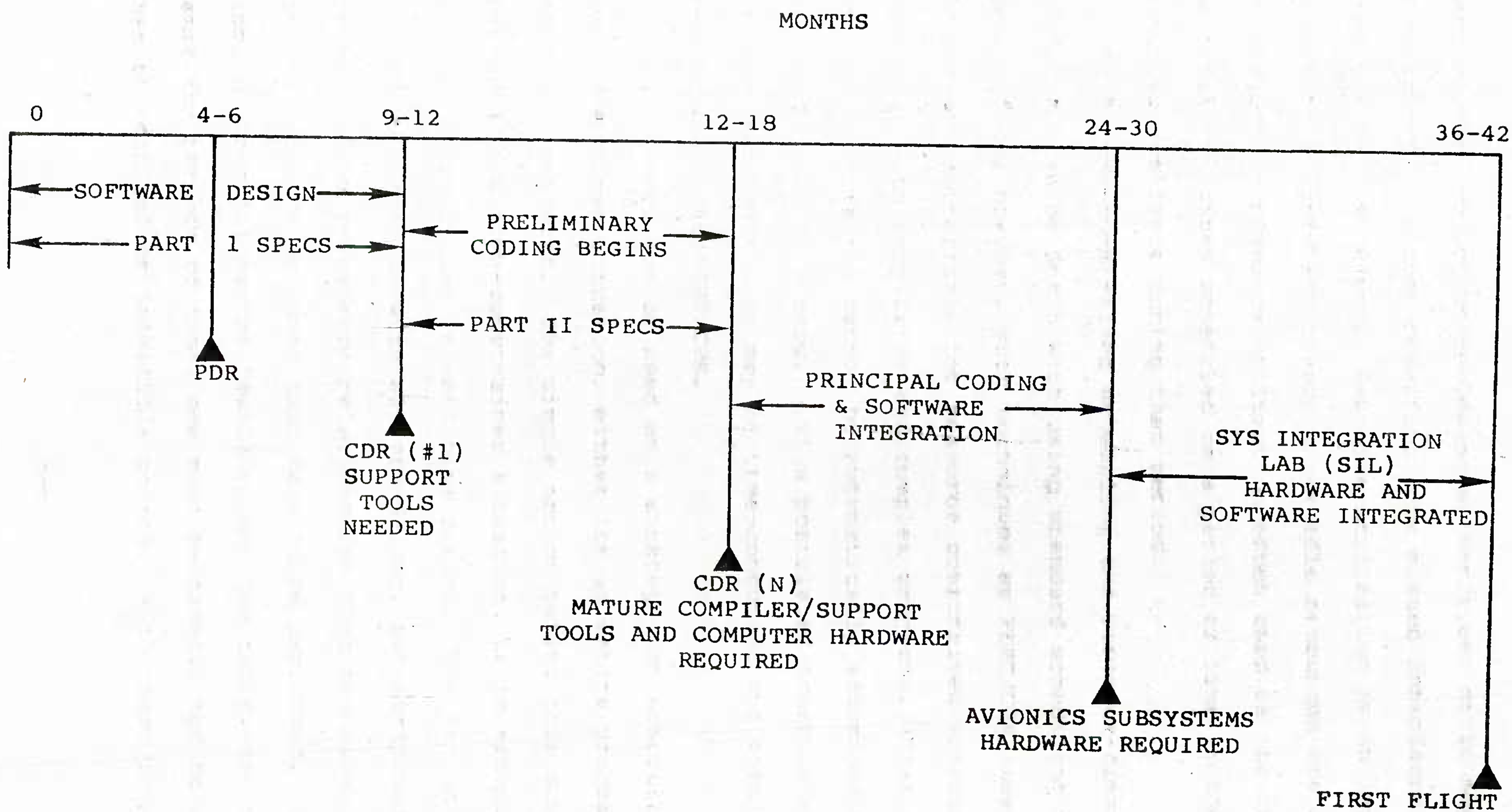


Exhibit 8-1. AVIONICS SOFTWARE DEVELOPMENT SCHEDULE

very detailed design is necessary for this component, since every pound of avionics added to an aircraft will increase the total aircraft weight by 4 to 10 pounds, depending on its placement on the craft. Taking shortcuts in this area can be very costly since requirements for power and cooling, in addition to aircraft weight and other design considerations, are affected. While these considerations apply to avionics software, similar situations occur for many other systems in specific weapon systems. These must be identified in developing the program schedules, particularly in applying concurrency.

When examining the use of concurrency as an acquisition stategy, one should consider the two relevant planning concepts:

- time-constrained scheduling, and
- resource-constrained scheduling.

In time-constrained scheduling, strategies would focus on alternative allocations of resources and sequencing of work that accomplishes a project in a fixed amount of time. Resource-constrained scheduling, on the other hand, is performed when resources (generally budgets, personnel, or equipment) are limited. In this case, one generally attempts to accomplish a project in minimum time within the resource limit.

Two criteria that are frequently used to measure the effectiveness of schedules are measures of project slippage and resource utilization. The first is used since there are generally penalty costs associated with not completing a project on time. Those penalties may be posed as lost "good will" with

users of the product or reviewing authorities; or it may be posed as an opportunity cost resulting from missed interfaces with other projects or plans. Resource utilization is an important measure of program efficiency since idle resources are costly. One measure of resource utilization often used is the ratio of the total resources scheduled in a period of time to the total resources available during that period.

Both time-constrained scheduling and resource-constained scheduling can be dealt with using standard scheduling techniques. Often, however, such techniques as PERT/CPM (see Chapter 10) are not appropriate for resource constrained scheduling, especially with very large and complex projects. That is because resource constraints cannot be automatically accommodated by the technique. As a result, if a postulated schedule violates a resource constraint, it may be time-consuming and costly to re-schedule using PERT/CPM.

Concurrency can be used as a strategy for scheduling in a time-constrained situation, either for an entire program or for individual projects. The simple notion behind this strategy, when used in a time-constrained situation, is to schedule all that can be scheduled in each time period. One has to be careful in this instance, as with all scheduling, but particularly here, not to violate precedence relationships that may exist among the various projects or tasks that have to be performed. In addition, although it may be feasible, and desirable, to interrupt tasks for periods of time, one must be careful not to interrupt them at critical or infeasible points. With these thoughts in

mind it is useful to look more closely at the analysis of risks in conjunction with the use of concurrency and some considerations involved in such an application.

CONCURRENCY APPLICATION CONSIDERATIONS

As has been mentioned throughout this handbook, the concept of concurrency can be applied in many different ways, for many different reasons. The following quote elaborates on this. While it is discussing concurrency in Navy ship acquisitions, the same applies to Air Force programs, as witnessed by the F-16 multistage improvement program.[2]

"Concurrency is often used in two areas of the acquisition process to minimize the time required to acquire a class of ships. First, there may be concurrency in the development of the detail design and early construction efforts. Normally it is expected that subsystems or equipments will be tested and accepted for fleet use before they are designated for inclusion in a new class of ships. However, situations may arise in which major improvements are anticipated from equipment currently under development. In those cases, a decision must be made on whether to accept the lower performance available from proven equipment or to accept some risk by continuing development of new equipments that promise to meet the projected performance goals and completion schedule.

"The second aspect of concurrency is ordering the early follow ships before the first ship has been delivered and tested. The decision on the timing of the award for early follow ships and start of construction of these ships should reflect a trade-off between an acceptable level of risk that the lead ship will satisfy the stated requirements and the desire to deliver follow ships as early as possible so that they will have maximum useful life. It is because of the latter reason that decisions are made on most ship acquisition programs to not utilize the lead ship as a true prototype for the remaining ships of the class. Another reason for rejecting the prototype approach is that the ship system as a whole generally incorporates hardware which is off-the-shelf, state-of-the-art and therefore does not pose the kind

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2/ Much of the following discussion has been adapted from Shortening the Acquisition Cycle: Research on Concurrency (Insley, et al, Management Consulting & Research, Inc., 30 September 1982.)

of risk posed by a system comprised for the most part of advanced-technology hardware.3/

Decisions on the use and placement of concurrency are contingent upon several conditions:

- the magnitude of the constraint, i.e., the amount of time that the schedule must be reduced;
- the portion of the schedule affected by the constraint, i.e., the activities remaining to be accomplished or which can be rescheduled; and
- the opportunity to analyze the risks and impacts of making the decision.

This analysis should be part of the overall effort to develop and update the acquisition plan/strategy. This means that the concurrency analysis should be initiated in the Concept Exploration phase and identified in the outline of the acquisition plan/strategy. There are two reasons for advocating early concurrency analysis:

- the earlier the process is incorporated, the earlier the alternatives and risks can be identified and monitored; and
- the initial analysis may be complex, however, once the apparatus for performing the analysis has been developed, subsequent reviews will be easier to implement.

Early planning also allows the gathering of the necessary information and organization of the schedule to facilitate the concurrency analysis from the beginning. This is particularly critical due to the need to identify tasks or activities which are analytically compatible. The concurrency analysis rests on the ability of the analysts to determine how much of an activity

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3/ "Relationship Between Acquisition Strategy and the Contract Design Package," Advanced Marine Enterprises, Inc., Arlington, Virginia, 22 February 1977.

is complete, or will be complete, at a given point in time.[4] This is used in the calculation of the degree of dependence the activity has on other activities, combined with the degree of uncertainty related to the resource projections. The degree of uncertainty, in turn, is related to how much of the activity has actually been completed at the time of the analysis, when the activity occurs in the sequence, how dependent the activity is on other activities, and how sensitive it is to exogenous factors. Exhibit 8-2 illustrates the degree of technological uncertainty at progressive stages of the acquisition process. A similar pattern exists in the accomplishment of activities within these stages. It may, however, be more useful to the PM to measure activities not in terms of amount of work completed but rather by the completion of the amount of time allocated for the task. The only requirement is that whatever measure is used allows for a meaningful comparison of the tasks.

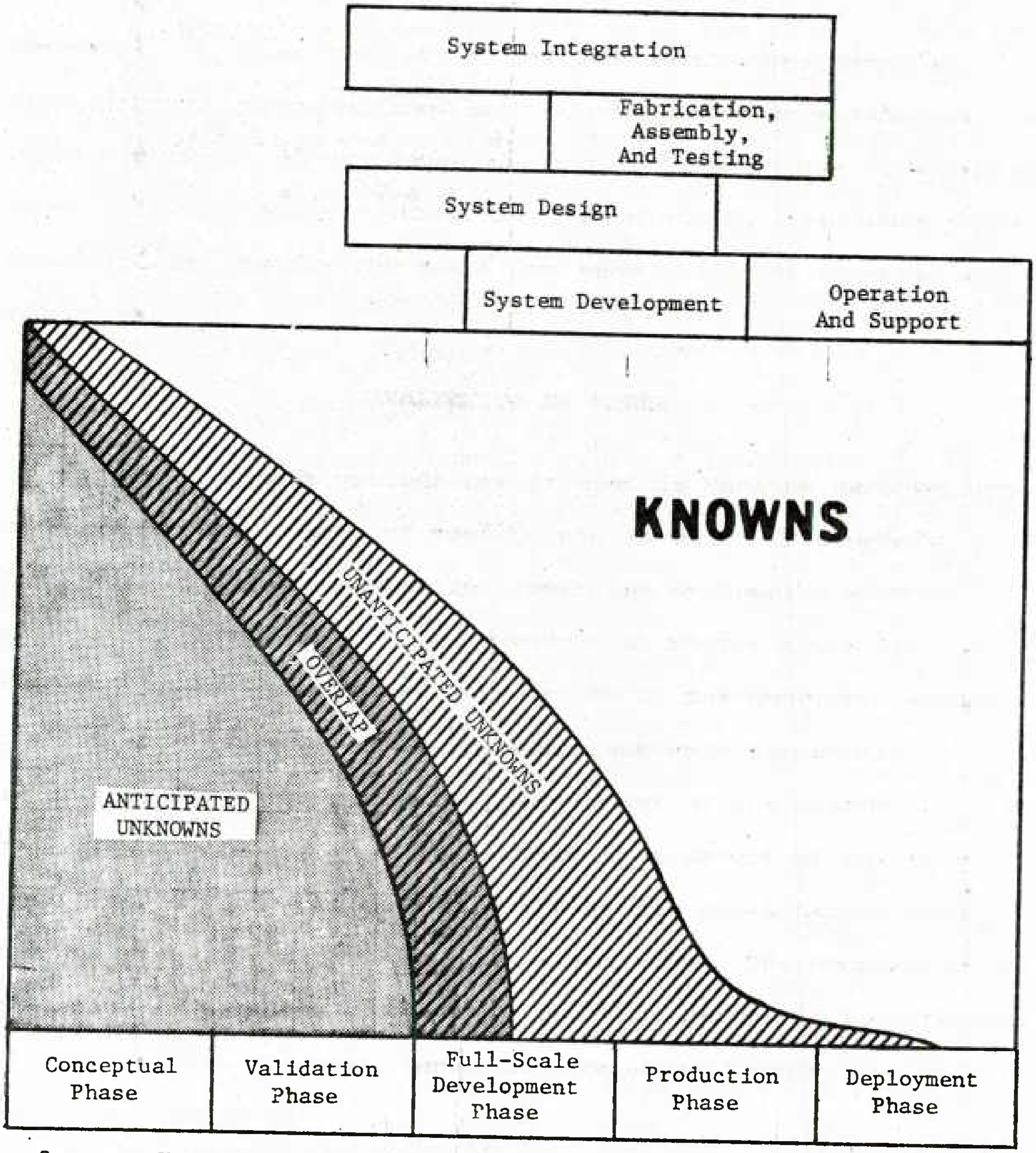
The ultimate goal of the analysis is to provide the decision maker with a method for:

- identifying activities which can be concurrently scheduled, and
- evaluating the cost, readiness and schedule risks associated with them.

In order to do this the analysts must ask a series of qualitative questions which assist in determining the:

- degree of activity dependence,

4/ Many program management guides describe standard techniques for analyzing work completed or programs. A brief discussion of this is given in the Guide for Weapon Systems Acquisition, (Huffman, Lozito, and Snyder, Air Command and Staff College, May 1981).



Source: K. E. Brandt, "Decision Risk Assessment and Analysis in the Weapons System Acquisition Process," USAF Aeronautical Systems Division, January 1974.

Exhibit 8-2. THE DEGREE OF TECHNOLOGICAL UNCERTAINTY AT PROGRESSIVE STAGES (RISK)

- amount of acceptable concurrency to be permitted among different activities, and
- amount of acceptable cost and schedule risk considered tolerable for the planned scope of the concurrency.

Questions which should be answered are, for example:

- What information is needed to begin the activity?
- What are the sources of this information?
- Are they under the control of the PM?
- How much of the activity has been completed at this time?
- How much of the tasks which provide input information to this activity must be complete before this activity can be initiated?
- Is the source activity (the activity or task providing information), expected to meet its schedule? If not, how uncertain is this schedule?

The analysis should use two different checklists. These checklists are to be used to:

- evaluate activities and events to determine concurrency options, and
- evaluate the cost, readiness, and schedule risks associated with the different schedule alternatives.

In identifying the concurrency options, activities are initially categorized in terms of those that:

- cannot be rescheduled, reorganized or reordered;
- might be possible to reschedule, reorganize or reorder, but for a variety of reasons are less desirable; and
- can be rescheduled, reorganized or reordered.

Initial emphasis would be placed on the third category. Assignment to any of the categories is based on current understanding of the conditions prevailing in the program. It is,

therefore, possible that activities previously considered as unlikely concurrency options may, after further consideration, be re-categorized. As mentioned in Chapter 7, the identification of potential concurrency options is of substantial importance since those options provide the basis for generating the alternative schedules.

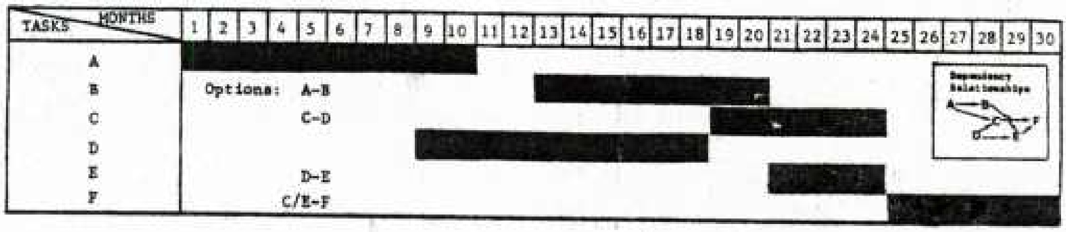
EVALUATION OF RISKS

The concurrency options are grouped in various combinations and with different sets of constraints in order to generate different schedules. An option comprises at least a pair of activities, composed of an independent or source activity, i.e., the activity which provides information to the dependent activity, and the dependent activity which succeeds the source activity and would begin before completion of the source activity. Options may actually comprise clusters of activity/event combinations, representing all of the sub-schedule activities related to a detailed schedule activity. The composition of an option is completely dependent upon the perceived requirements of the project. However, generally, dependent activities within an option should be:

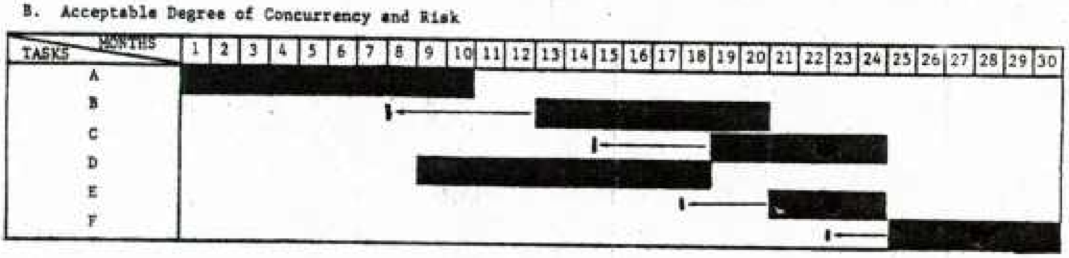
- under the control or direction of the PM, and
- influence the project cost or schedule duration.

Exhibit 8-3 illustrates the basic relationship of concurrency options to alternative schedules. A sequence of activities, Tasks A through F, is shown. Based on analysis of the

A. Baseline Sequence with Options



B. Acceptable Degree of Concurrency and Risk



Option	Degree of Concurrency	Acceptable Target Degree of Cost Risk*	Acceptable Target Degree of Schedule Risk*
A-B	• B + 5 Months/37.5%	.10	.15
C-D	• C + 4 Months/66.7%	.30	.20
D-E	• E + 3 Months/25.0%	.05	.10
C/E-F	• F + 2 Months/33.3%	.20	.15

* Degree of Risk = Probability of failure to meet estimated cost or schedule.

C. Alternative Schedule

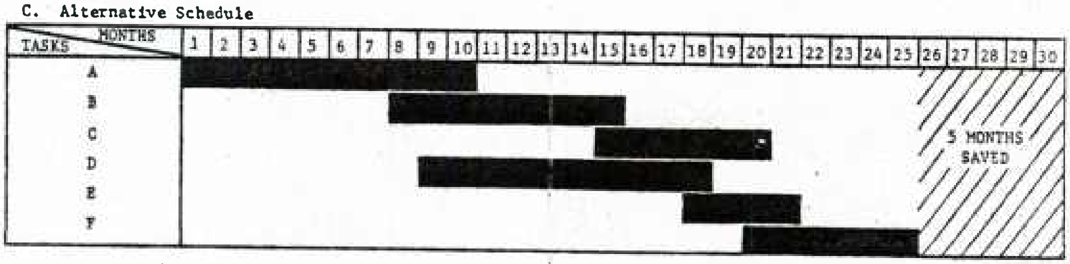


Exhibit 8-3. RELATIONSHIP OF CONCURRENCY OPTIONS TO ALTERNATIVE SCHEDULES

dependency relationships, the degree of uncertainty associated with them, and the role of each task in the total sequence, options are selected. The options, any or all of which may be used in generating the alternatives, are:

- overlap of B with A, A-B option;
- overlap of C with D, C-D option;
- overlap of E with D, D-E option; and
- overlap of F with both C and E, C/E-F option.

Having determined the options, limiting values must be developed to use in generating the alternative schedules. The characteristics which are manipulated for each alternative are:

- the applicable concurrency options,
- the related resource estimates for each activity on the schedule (reflecting the additional constraints),
- the maximum acceptable degree of concurrency for each option, and
- the maximum acceptable degree of cost and schedule risk for each option.

Alternatives are structured taking into account the degree of uncertainty associated with the initial estimates. Part C of Exhibit 8-3 shows the alternative generated, based on the selection of options and tailoring of values for the characteristics.

After generating the various alternatives, it is necessary to evaluate the risks of each in terms of cost and schedule. The basic tools in this analysis are the cost risk evaluation checklists and the schedule risk evaluation checklists. They are designed to address the concerns the decision maker must keep in

mind in order to weigh the alternatives. Exhibits 8-4 and 8-5 are examples of the kinds of considerations necessary for development of the checklists. Actual checklists would have to be tailored to the particular application at hand. The purpose of the risk evaluation is not only to estimate the potential risk associated with each alternative, but also to rank the appropriateness of each alternative. It is possible to generate alternatives with mutually conflicting cost and schedule constraints or risks.

Exhibit 8-6 illustrates the results of evaluating the alternatives generated in the example given in Exhibit 8-3. In addition to calculating the total amount of time saved, the specific cost and schedule tasks must be calculated for each option as well as the total for the alternative. As part of this analysis, it is also important to determine the "peak" risk, i.e., the options with the highest potential cost and schedule risk. This is particularly important if the potential risk is higher, or related to a different option than the original "target" degree of risk, as illustrated in this example.

The effectiveness of the application of the concurrency analysis methodology can be quantified once this analysis has been made. Suppose that the portion of interest in the schedule for a particular project cannot be completed in less than T_O units of time, say months. Suppose further that the baseline schedule for that portion of the project has a duration of T_B months. If a concurrent schedule will complete the project in T_C

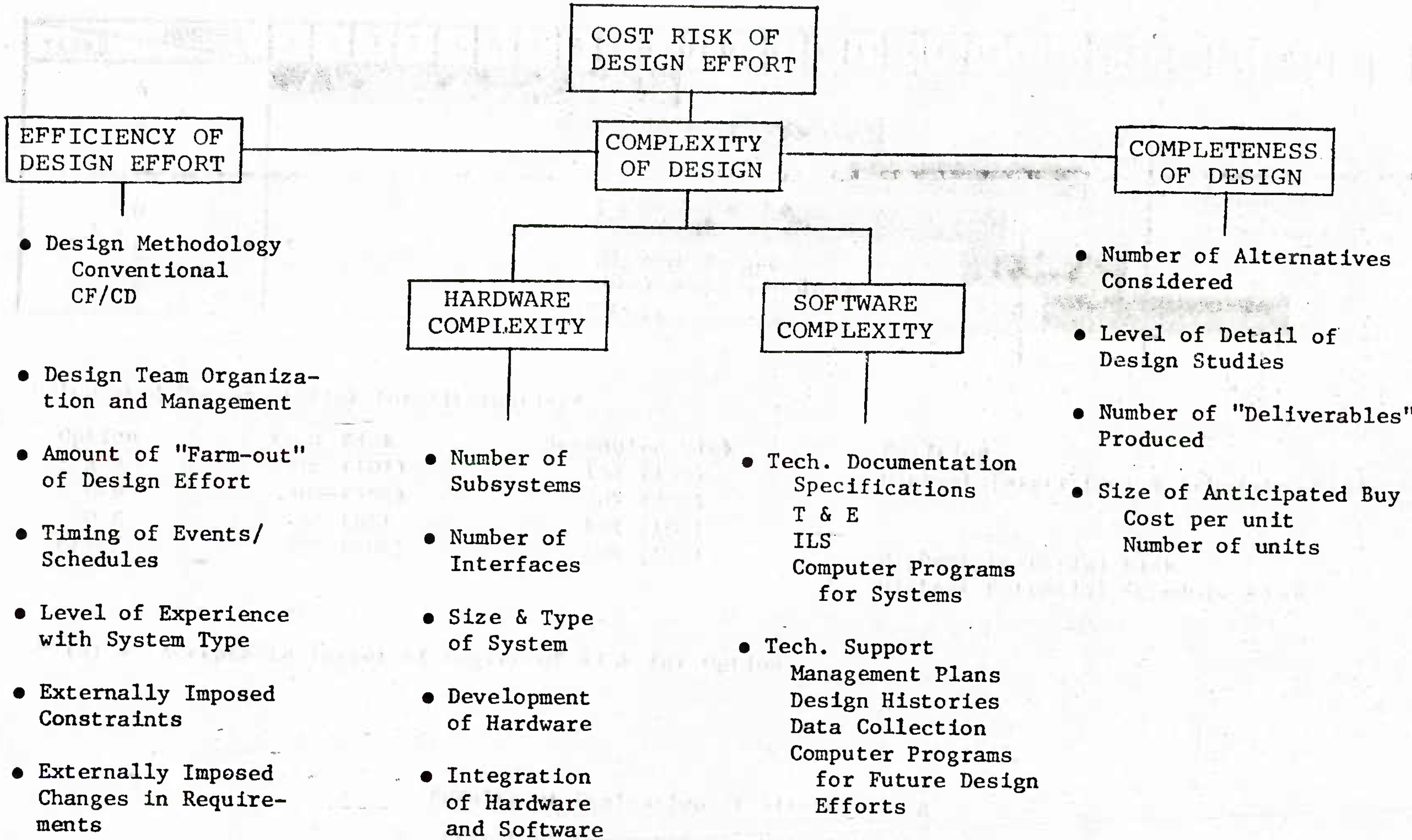


Exhibit 8-4. COST RISK CONSIDERATIONS IN SYSTEM DESIGN

- Is the activity dependent on information or inputs from outside the performing organization?

- Is the manpower within the performing organization subject to fluctuation; i.e., is the performing organization responsible for performing similar activities for other programs and, therefore, the manpower must be competed for?

  - Does the ability to compete (or lack thereof) indicate relative value or importance and, therefore, can the program expect to have lower priority in other areas?

- How much of the input information is needed in order to begin the dependent activity?

- Is development of the input information from outside of the performing organization on time? Do they expect it to stay on time?

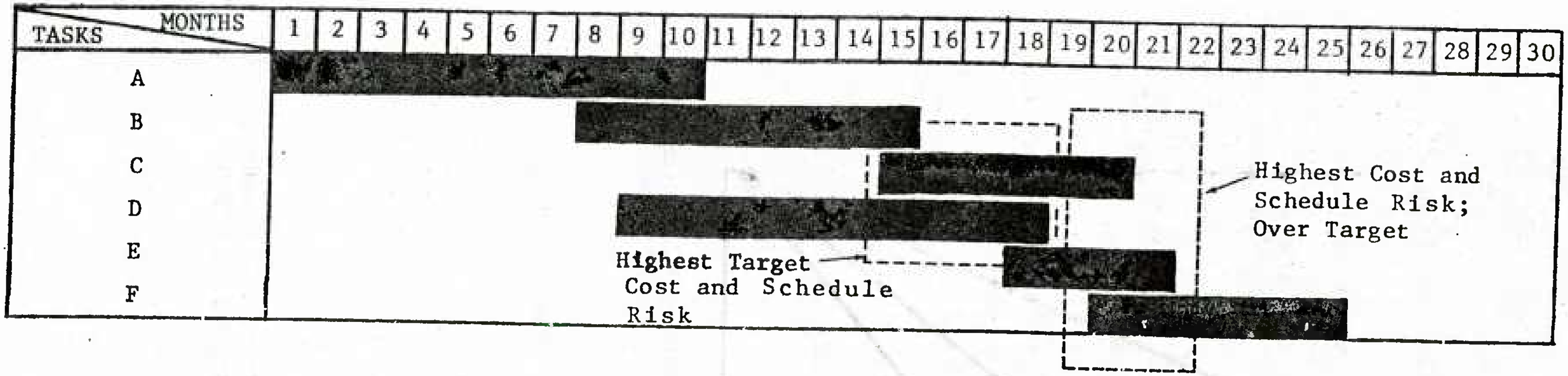
- What other parts of the schedule are dependent on this information? Information from this group?

- Has allowance for schedule slippage been incorporated in the time estimate?

- Have additional quality assurance measures been identified in order to reduce potential risks associated with concurrently scheduling the activity?

Exhibit 8-5. SCHEDULE RISK CONSIDERATIONS

Alternative A.



Calculated Degree of Risk for Alternative*

Option	Cost Risk	Scheduled Risk	Position
A-B	20% (10%)	15% (15%)	Highest Target Cost & Schedule Risk
C-D	30% (30%)	20% (20%)	
D-E	5% (5%)	15% (10%)	
C/E-F	35% (20%)	40% (15%)	Highest Potential Risk Highest Potential Schedule Risk

* (%) = Acceptable Target of Degree of Risk for Option

Results of Evaluation of Alternative A

Effect of Concurrency: Gain 5 Months
Total Cost Risk:
Total Scheduled Risk:
Peak Cost Risk:
Peak Scheduled Risk:

Exhibit 8-6. EVALUATION OF ALTERNATIVE SCHEDULE

months, then one measure of the effectiveness of the concurrency accomplished by the latter schedule is:

$$D_C = \frac{T_B - T_C}{T_B - T_O} .$$

Clearly, this is a relative measure since, for any given project, the potential effectiveness of applying concurrency will change as the completion time for the baseline schedule changes and the schedule progresses. Simply stated, this measure of the degree of concurrency gives the percent of time that can be saved in the baseline schedule that is actually saved by implementing the concurrent schedule.

Generally speaking, projects are not completed in the shortest possible time, e.g., in T_O years. That is because of budget limitations or the risks, technological and otherwise, that are introduced as one tries to shorten the acquisition time. Thus, the degree of concurrency sought, D_C, must be balanced against the risk of successful program completion within a specified budget and time, and producing a specified level of product performance.

In Exhibit 8-7 D_C is plotted, for varying levels of T_O/T_B, against the term $(T_B-T_C)/T_B$. As used here, (T_B-T_C/T_B) is a measure of the percent of the time it takes to complete the baseline schedule that is saved by implementing the schedule with concurrency.

In selecting the alternative which will be used to revise the existing schedule, the decision maker must take into consideration the other scheduling alternatives which can be used in conjunction with concurrency.

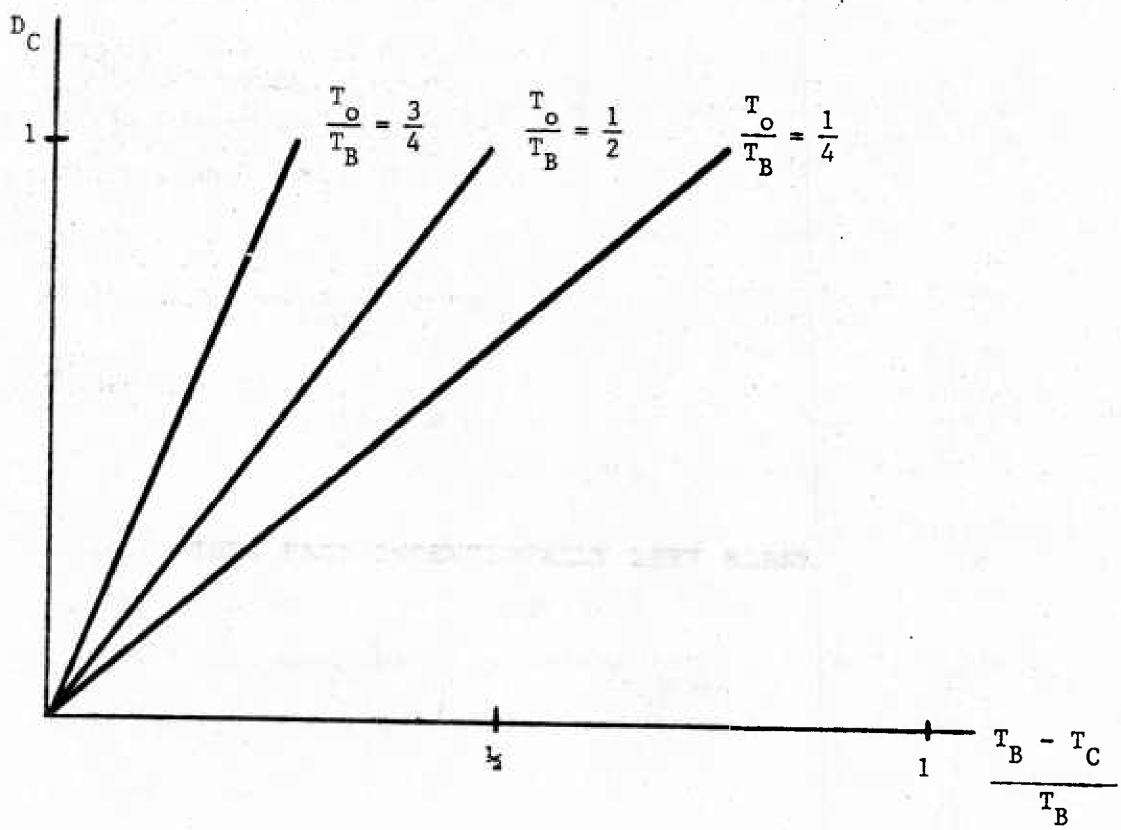


Exhibit 8-7. THE DEGREE OF CONCURRENCY REALIZED AS A FUNCTION OF THE PERCENT OF THE BASELINE TIME SAVED

Some of the alternatives the decision maker (or PM) should consider are:

- funding of parallel activities, in order to increase the probability that one of the alternatives will successfully meet the goals of the program;
- funding repetition of activities, when a critical activity has not been previously successful;
- scheduling activity "slack time," to allow for the unforeseen extension of the duration of an activity; and
- lowering performance objectives of a high-risk activity and compensating by increasing the performance requirement for a lower risk activity.

The ultimate set of decisions made by the PM must reflect the particular needs of the project.

PART IV. OVERVIEW OF RISK ANALYSIS

Chapter 9. Elements of Risk Analysis

Chapter 10. Risk Analysis Alternatives

PART IV. OVERVIEW OF RISK ANALYSIS

One of the major concerns in this handbook is the consideration of how to best manage risks to materiel readiness in developing a new system. In order to effectively consider this, it is necessary to consider the actual nature of risk analysis, how it is conducted and the role it plays in program management. The latter is discussed throughout this handbook. The chapters in this section of the handbook focus on the nature of risk and the elements of risk analysis (in Chapter 9), and some of the tools and alternatives available to the Program Manager in examining risks (Chapter 10).

CHAPTER 9. ELEMENTS OF RISK ANALYSIS

- The Requirement for Risk Analysis
- The Nature of Risk and Uncertainty
- Phases of Risk Analysis

CHAPTER 9. ELEMENTS OF RISK ANALYSIS

The four principal elements in the acquisition of a major system are program cost, the development and production schedule of the program, the performance that the system will achieve, and the supportability and readiness requirements of the system. Effectively balancing these four elements becomes increasingly difficult as systems become more costly and more complex technologically, and their introduction into the force becomes more time-critical. In attempting to balance the four elements of cost, schedule, performance, and readiness, DoD planners and managers have instituted a series of initiatives that address various aspects of the acquisition process. One set of those initiatives addresses, among other things, the need to consider alternative acquisition strategies and the resulting requirement to evaluate the effectiveness of those strategies. Among the reasons for this requirement has been the tendency toward cost growth and schedule slippage on many military acquisition programs.

This chapter contains a review of selected guidance requiring the performance of risk analysis in acquisition programs, and covers aspects of risk analysis that include:

- relevant definitions and an explanation of the distinction between risk analysis and uncertainty analysis,
- the role of risk analysis in acquisition planning, and
- analytic considerations that must be addressed in performing a risk analysis.

THE REQUIREMENT FOR RISK ANALYSIS

On 31 July 1969, then Deputy Secretary of Defense David Packard instructed each of the Service Secretaries to ensure that, during concept formulation: "areas of high risk are identified and fully considered; formal risk analysis on each program is made; and summaries of these are made part of the backup material for the program."1/ In September 1969, then Secretary of the Air Force Robert Seamans noted the following:

> "Still another significant reason for cost growth in the last few years has been the failure to adequately identify the risks associated with major programs. This should occur early in the project definition phase. Late recognition of significant uncertainties can be disastrously expensive. In the future, we will make a formal risk analysis of each of our programs. We must guard against the combination of optimistic pressures, including our own eagerness to get on with the job."1/

During the 1970s, directives and implementing instructions formalized the risk assessment requirement for major system acquisitions. On 5 April 1976, the Office of Federal Procurement Policy within the Office of Management and Budget (OMB) issued OMB Circular No. A-109, Major Systems Acquisitions. That document states a requirement to:

- perform coordinated mission planning that results in requirements stated in terms of mission needs rather than hardware specifications,
- examine alternative procurement actions for meeting the stated mission needs, and
- develop acquisition strategies that are tailored to individual programs.

1/ Lenox, Hamilton T., Risk Assessment, Air Force Institute of Technology, Wright-Patterson AFB, Ohio, June 1973.

As part of the acquisition strategy for new acquisitions, the circular also requires an evaluation of the risks involved in the acquisition.

DoD Directive 5000.1, Major System Acquisitions (29 March 1982), states that the phases of the acquisition process for a new system "are to be tailored to fit each program to minimize acquisition time and cost, consistent with the need and the degree of technical risk involved." Moreover, that directive states that the decision to procede to full-scale development may be delayed "until some additional development effort has been accomplished to provide better definition of performance, cost, schedule, producibility, industrial base responsiveness, supportability, and testing to reduce risk and uncertainty before the commitment to a major increase in the application of resources toward full-scale development is made."

On 31 March 1982, then Deputy Secretary of Defense Carlucci outlined 32 initiatives (the "Carlucci Initiatives") planned to improve the system acquisition process within DoD. Of the 32 initiatives, seven directly influence the use of concurrency as an acquisition strategy and one, Action 11 - Technological Risk Funding, directly addressed risk in the acquisition process.

In DoD Instruction 5000.2, Major System Acquisition Procedures (8 March 1983), the specification for the System Concept Paper (prepared for Milestone I) requires that the System Program Office clearly identify those key areas of technological risk that have to be reduced before the Milestone II decision. That same instruction requires that the Decision Coordinating

Paper (prepared for Milestone II) explain how test and evaluation results indicate resolution of significant risks.

DoD Directive 5000.39, Acquisition and Management of Integrated Logistic Support for Systems and Equipment (17 November 1983), states that acquisition strategies will emphasize "evaluation of alternative support concepts and techniques to minimize cost and support risks."

Finally, MIL-STD-1388-1A, Logistic Support Analysis (11 April 1983), provides guidance for identifying early requirements for analyses that can be performed to obtain a balance among cost, schedule, performance, and supportability.

Risk analysis, as an aid in analyzing acquisition strategies is thus a necessary part of the analyses performed during the course of the system acquisition process.

THE NATURE OF RISK AND UNCERTAINTY

Generally speaking, there are three states of knowledge into which a given circumstance may be classified. The circumstance may involve "knowns," i.e., facts and issues for which no further resolution is necessary. It may involve "known-unknowns," i.e., elements which are known to require resolution, but for which further analysis is necessary or certain assumptions must be made. Finally, the circumstance may involve what are called "unknown-unknowns," i.e., unanticipated situations that cannot be predicted before they occur. The latter include random events and externalities over which one has no control.

It is useful at this point to consider examples of the second and third states of knowledge since they help form the basis of definitions of risk and uncertainty. An example of a situation that involves "known-unknowns" is the fabrication of a wing for a new airplane using conventional design and manufacturing techniques. Although there are a number of problems that would have to be resolved here, they are well known and have been dealt with many times before. "Unknown-unknowns," on the other hand, were the cause of the serious instability experienced with early large liquid fuel rockets. The cause was eventually determined to be "fuel sloshing." This had not been anticipated since there was no prior experience in this area and analysis had not predicted this phenomenon. Only after the loss of several rockets was the cause determined.[2/]

Although the terms risk and uncertainty are often used interchangeably, strictly speaking, they are quite different technically. The following are accepted definitions and are the focus of theoretical work and work on analytical techniques:

- Certainty is a term used to describe situations in which each action is known to lead invariably to a specific outcome.

- Risk enters in when each action leads to one of a set of possible outcomes, each outcome occurring with a known probability.

- Uncertainty is present when each action has as its consequence a set of possible specific outcomes, but

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2/ George, B. M., "The Weapon Systems Development Process," Government Procurement and Contracting (Part 9), Hearings Before a Subcommittee of the Committee on Government Operations, House of Representatives, Ninety-first Congress, First Session on H. R. 474, 1969.

the probabilities of those outcomes are either completely unknown or are not meaningful. 3/

There are many factors that may lead to risk and uncertainty in an acquisition program. Some of those factors come about due to the complexity of the decision making that must be done. Typically a Program Manager must make decisions in an environment that imposes multiple, sometimes conflicting, objectives, and often it will be difficult to even identify, let along choose among, alternative courses of action. The conflicting objectives come about for a number of reasons, including the presence of several decision makers to whom the Project Manager is responsible and must respond, and a system operational environment that includes many impacted groups.

Uncertainty in the decision making process enters as a result of many intangibles that are generated by the particular technologies involved, the program planning and weapon system operational environments involved, data uncertainty, requirements for subjective judgement, and trade-offs among alternatives. Unpredictable disruptions that cause a gap in program execution may occur in a program, resulting in a requirement to stretch a program over a longer time for lack of funding or because key milestones could not be met. Even uncertainty in aspects of models used for analysis can have an effect if unpredicted results arise due to model misspecification or data uncertainty.

Not the least measure of uncertainty is imposed by unanswered (or unanswerable) questions concerning the threat to

3/ Luce, R. D. and Raiffa, H., Games and Decisions, John Wiley, 1957; see also Final Report of the USAF Academy Risk Analysis Study Team, Aeronautical Systems Division, August 1971.

which a particular system is designed to respond. Rapid technological advances and changing operational environments make it particularly difficult to do accurate long-range planning without accepting some jeopardy to the program cost or schedule, or to weapon system performance. These factors can materially affect the successful performance of an acquisition program.

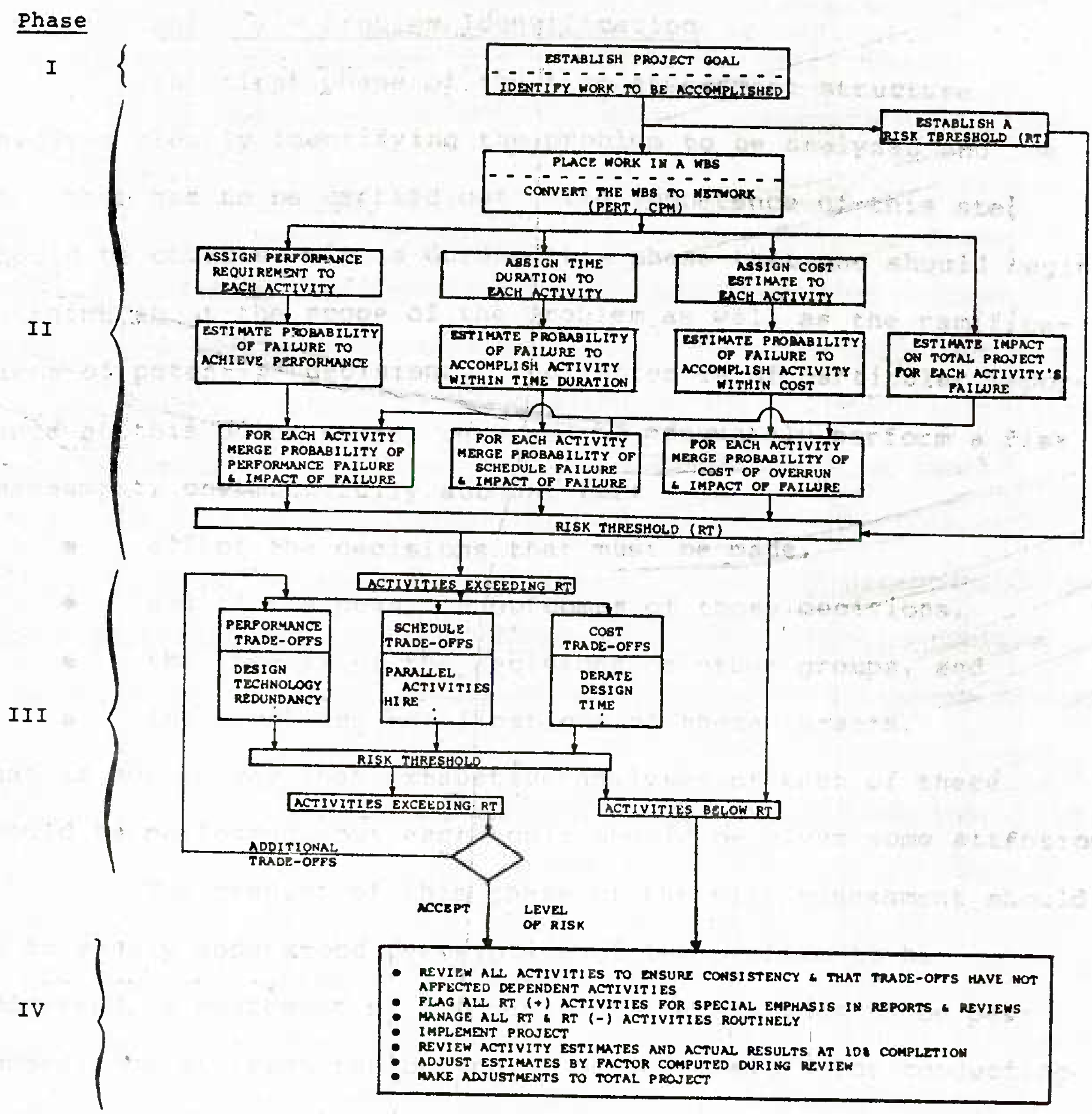
PHASES OF RISK ANALYSIS

In order to make reasonable acquisition management decisions, a risk analysis following the structure displayed in Exhibits 9-1 and 9-2 might be performed. The approaches that are illustrated are fairly general and are readily tailored to individual problems. Using them to structure an analysis should prove useful.

Conceptually, at least, the approaches that are illustrated can be thought of as consisting of four phases:

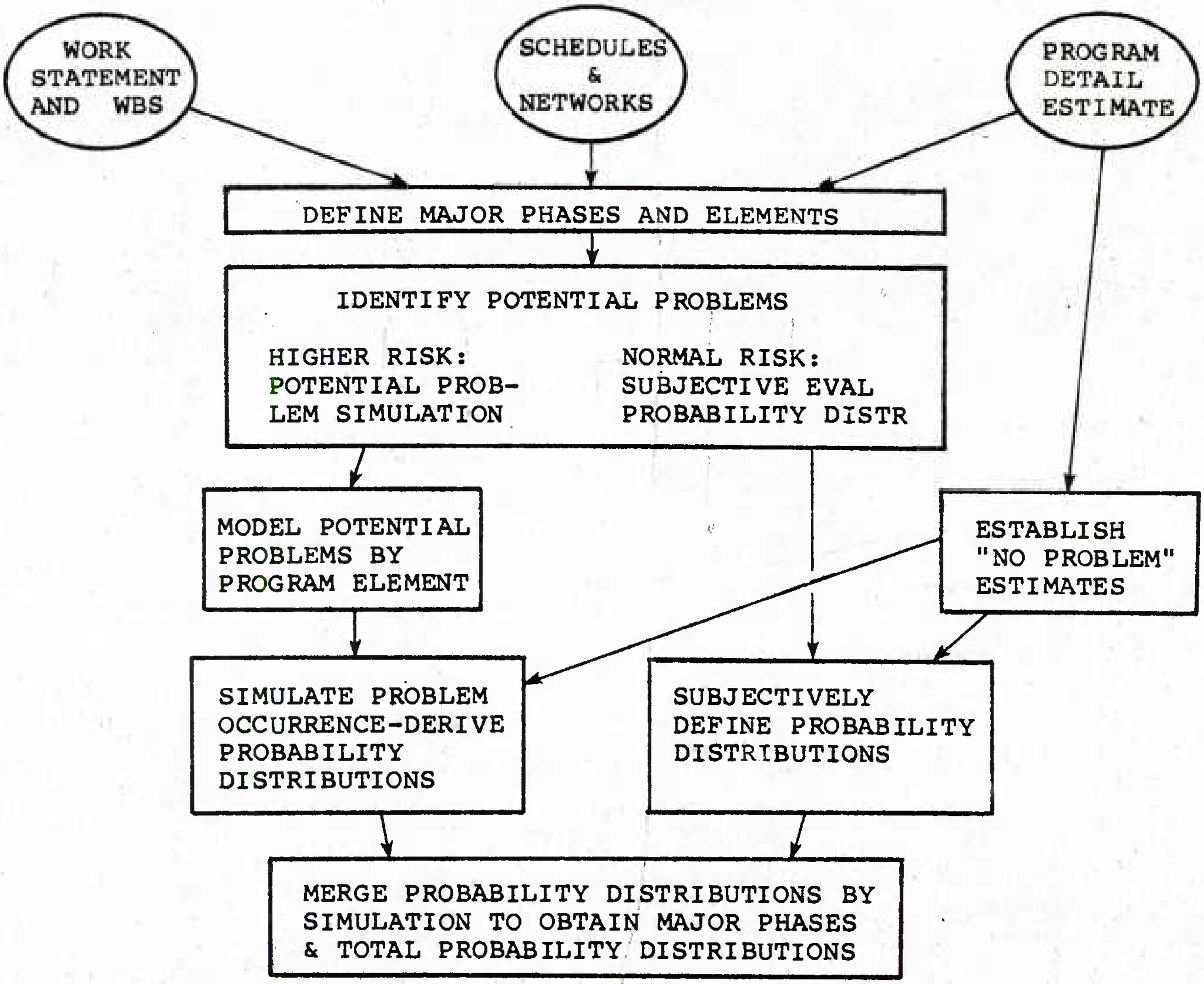
- Phase I - Problem Identification,
- Phase II - Problem Formulation,
- Phase III - Analysis, and
- Phase IV - Evaluation.

Each of these phases is discussed below and specific elements of these phases are explained in the following subsections. These phases are labeled on Exhibit 9-1 to enhance the discussion. Because of the nature of the graphic display in Exhibit 9-2, it is more difficult to clearly identify each phase without complicating the illustration. In addition, although the impression one



Source: Ireland, L. W., <u>A Risk Management Model for the Defense System Acquisition Process</u>, SWL, Inc., McLean, Virginia (undated).

Exhibit 9-1. A SAMPLE STRUCTURE FOR A RISK ASSESSMENT



Source: Kraemer, George T., A Successful Quantitative Risk Assessment Technique, Boeing Vertol Company (undated)

Exhibit 9-2. A SAMPLE RISK ASSESSMENT FLOW DIAGRAM

gets from the two exhibits and the following discussion may be that this construct is designed for large risk analysis problems only, it applies equally well to small problems.

1. <u>Phase I - Problem Identification</u>

The first phase of the risk assessment structure involves clearly identifying the problem to be analyzed and the work that has to be carried out. The importance of this step should be obvious. It is during this phase that one should begin to think about the scope of the problem as well as the ramifications of potential decisions. The latter is of particular importance at this point since, in order to adequately perform a risk assessment, one must fully account for:

- all of the decisions that must be made,
- all of the possible outcomes of those decisions,
- the impacts of the decisions on other groups, and
- the resulting ramifications of those impacts.

That is not to say that exhaustive analyses of each of these should be performed, but each topic should be given some attention.

The product of this phase of the risk assessment should be an easily understood description of the problem to be addressed, a statement of the goals of the analyses to be performed, and at least the beginning of a framework for conducting those analyses.

2. <u>Phase II - Problem Formulation</u>

In the problem formulation phase, one must fully

describe the problem(s) at hand and decide in very precise terms exactly what is desired by way of analysis. It is in this phase that conceptualization of the problem occurs insofar as analytical constructs for treating the problem are suggested. If, for instance, the problem is one of developing a master program schedule, this phase of the work would involve steps designed to identify:

- those elements of the program to be covered by the project schedule,
- the techniques to be applied in formulating and displaying the schedule,
- the particular analyses to be performed to resolve specified issues, and
- the analysis teams to carry out the next phase of the assessment structure.

In the particular example cited, i.e., developing a master program schedule, the first step would result in specification of those aspects of the program to be considered and the level of detail to which each aspect will be included. The various levels that could be considered include the following hierarchy of acquisition program components:

- Phases - The major acquisition phases, as defined by DoD Directive 5000.1, are: Concept Exploration, Demonstration and Validation, Full-Scale Development, and Production.
- Functions - The major categories of work performed in, or under the direction of, the Program Office, include Technical Management, Logistics Management, Business Management, and other general categories of work activity and Project Office responsibility.
- Task Areas - These are the subtasks of functional work such as those that come under Technical Management, i.e., hardware design, software design, test and evaluation and others.

- Events - These are the key points in a Task Area that identify the beginning or end of some segment of work. Examples are document delivery, design review meetings, milestones, and initiation of document preparation.

- Activities - Many individual efforts are often involved in order to achieve satisfactory accomplishment of an event. Examples of these efforts, which involve preparation for a particular ending event, or which follow a starting event, include preparation of a baseline schedule, and review of a procurement plan.

- Organizations - There are often many organizations involved in the work of the Program Office. These groups are responsible for performing activities as either Program Office functional groups or contractors.

Each of the six components listed above plays a critical role in the planning and analysis of the Program Office. Each represents a different level of detail at which program planning can be done.

Once the appropriate level of detail is determined, the range of techniques that can be brought to bear on the problem should be considered. The actual selection of a technique should consider:

- the resources required to implement the technique, i.e.,
  - personnel,
  - time, and
  - cost;
- the availability of data needed to support the alternative techniques; and
- the robustness of the technique, i.e., the sensitivity of the solution, as a function of the technique, to changes in parameters including:
  - data,
  - particular algorithms used,

- precision of the computations, and
- user group.

As a result of the problem identification phase, there should be a concise statement of the problem to be treated. Implicit in the statement of the problem is a set of questions that must be answered or at least addressed. The analyses that will be performed, given the level of detail and the techniques chosen, must be targeted at the particular questions raised. Once the analyses are decided upon, one can assemble the individuals most suited to solving the problem at hand.

Once problem formulation is complete, analyses may begin.

3. Phase III - Analysis

The analysis, or implementation phase, is the phase in which the chosen techniques are used to answer the questions raised. In this phase, attention should be paid to the level of detail deemed appropriate and to the accuracy of the data used.

Because of the possibility of pressures imposed from outside the Program Office, earlier decisions may have to be re-evaluated during this phase. As a result, alterations in the actual implementation may have to be made.

4. Phase IV - Evaluation

No analytic structure is complete without an evaluation phase. During this phase one should consider:

- the consistency of the analysis results with what is already known or highly suspected,

- the direct impact of those results on the project, and
- the ramifications of the results on the interfaces that the Program Office must have with other organizations.

Once this is done, additional analyses may be warranted or the task may be deemed complete.

The phases of the risk assessment structure have been categorized differently by a number of individuals. One instructive way to group the various activities involved is shown in Exhibit 9-3. That exhibit not only poses the activities slightly differently, but also introduces a number of terms that relate to the different components of analysis of risk.

Risk analysis is the general process we have been discussing in this section. As seen from the discussion above, it is the process of examining the probabilities and consequences of the outcomes of a set of decisions. Risk analysis is typically used to assess the degree to which a proposed system is likely to achieve its predicted performance within cost and schedule goals. The overriding objective of risk analysis is risk reduction or at least risk management. Risk management refers to those actions implemented with the expressed purpose of reducing the number of program factors at risk or reducing the level of risk for those factors. The factors that are at risk are identified by way of procedures and analyses that are referred to as risk assessment.

The next chapter of this report describes a number of techniques that have been successfully used in performing risk analyses in acquisition programs for the Department of Defense.

PLANNING

EVALUATION
Risk Assessment

ALTERNATIVE CREATION

ALTERNATIVE EVALUATION
Risk Assessment

ALTERNATIVE SELECTION
Risk Reduction

IMPLEMENTATION
Risk Reduction
Risk Management

RISK ASSESSMENT

RISK REDUCTION

RISK MANAGEMENT

RISK ANALYSIS

Source: Defense Systems Management College, Risk Assessment Techniques: A Handbook for Program Management Personnel, July 1983.

Exhibit 9-3. COMPONENTS OF RISK ANALYSIS

CHAPTER 10. RISK ANALYSIS ALTERNATIVES

- Network Techniques
- Simulation Methods
- Graphic and Analytical Methods
- Data Requirements

CHAPTER 10. RISK ANALYSIS ALTERNATIVES

Most of the techniques that are generally applied in risk analyses can be classified into the following categories:

- network techniques, including
  - PERT (Program Evaluation and Review Technique),
  - VERT (Venture Evaluation and Review Technique),
  - CPM (Critical Path Method),
  - TRACE (Total Risk Assessing Cost Estimate), and
  - RISKNET;
- simulation methods, such as
  - RADSIM (Research and Development Assessment Model), and
  - WBS (Work Breakdown Structure) Simulation;
- graphics techniques like Gantt Charting; and
- analytical methods such as
  - CER (cost estimating relationship) development,
  - cost/benefit analysis, and
  - decision analysis.

These are just some of the many tools available for analyzing the risks associated with the acquisition of major systems.

Since there are quite a few references on risk analysis that are readily available (see Appendix A), this chapter only contains a brief overview of risk analysis techniques. More discussion of particular risk analysis techniques may be found in the references listed in Appendix A, especially the reference <u>Risk Assessment Techniques: A Handbook for Program Management Personnel</u> by the Defense Systems Management College.

NETWORK TECHNIQUES

Network techniques have come to be widely used in program management as a way to plan and evaluate the schedule for accomplishment of program activities. Many of the applications in use today have evolved from the successful application of a technique called PERT (Program Evaluation and Review Technique) on the Polaris Submarine Program.

PERT is especially useful on complex, multi-activity programs. In addition to providing an analytic structure for organizing and scheduling program activities, PERT analysis provides information that is helpful for evaluating program schedules. It allows identification of the critical paths among program activities, as well as the shortest time and least-cost paths. PERT can also be used to determine the probability of completing the entire program, or some segment of it, and so is very useful for risk assessment.

Statistical PERT is a variation of PERT that involves simplification of a network by partitioning it and modeling subsets of it separately. This technique is used on programs where very large networks are required to adequately represent program activities. It can also be used to perform in-depth analysis of program modules for which a separate scheduling network can be devised.

The Critical Path Method (CPM) is similar to PERT, however it does not use simulation, and emphasizes time/cost trade-offs, whereas PERT generally treats these parameters individually. As

with all network techniques, CPM requires that the program activities be expressed in terms of nodes (milestones, tasks, or decision points) and arcs (tasks or resource requirements). There is standard software that permits quick solution of problems set up for the use of CPM, and, depending on the size of the application, CPM can be used on micro-, mini-, and mainframe computers.

VERT, which is applicable to programs where performance is measured in terms of time or cost, offers the capability of modeling performance values for each activity singly or jointly. As with most network simulation methods, application of VERT can require substantial amounts of data. There is considerable flexibility with VERT, however, in that 14 probability distributions are embedded in VERT computer software and can be used in modeling a program schedule.

TRACE-P (Total Risk Assessing Cost Estimate for Production) is an integration of VERT and WBS (work breakdown structure) techniques. This technique is used for risk assessment/contingency funding in the first few years of system production. The essential innovation in this technique is that a direct link is made between WBS elements and the production schedule.

RISKNET has been used in a variety of complex programs with multiple activities and milestones where it is desirable to express total program risk in terms of cost or time requirements. RISKNET requires a mainframe computer for its operation. It allows the user to perform sensitivity analyses and provides an opportunity to model stochastic elements of program scheduling.

SIMULATION METHODS

RADSIM and WBS Simulation are two techniques that use simulation as the basis for evaluating the elements of a program that are at risk. RADSIM, which is similar to PERT, analyzes those data that describe the technical expectations of all R&D activities that are potential problem areas. In order to do that, the user must specify the logic by which the program is structured and the data that describe the strategy by which the program is to be conducted. WBS Simulation, as its name implies, uses a work breakdown structure in generating a total program cost estimate. Individual cost estimates for elements of the WBS are described by probability distributions. The total program cost is then derived probabilistically as the sum of the various (probabilistic) component costs.

There are a number of general purpose simulation languages that can be used in risk analyses. These include CSMP (Continuous System Modeling Program),[1/] SIMSCRIPT,[2/] GPSS (General Purpose System Simulation),[1/] and GASP (General Activity Simulation Program).[3/]

1/ Gordon, G., System Simulation, Prentice-Hall, Englewood Cliffs, New Jersey, 1969.

2/ Wyman, F. P., Simulation Modeling: A Guide to Using SIMSCRIPT, John Wiley & Sons, New York, 1970.

3/ Pritake, A. B., and Kiviat, P. J., Simulation with GASP II: A FORTRAN Based Simulation Language, Prentice Hall, Englewood Cliffs, New Jersey, 1969.

GRAPHIC AND ANALYTICAL METHODS

Graphical methods include analysis of descriptive statistics of stochastic variables as well as techniques such as Gantt Charts and control charts. These methods provide a visual display of important variables (e.g., program cost, probability of success or failure, system performance) as a function of one or two (for 3-dimensional plots) parameters such as time, resources, and system parameters (weight, range, reliability factors, etc.).

Analytical methods include such techniques as:

- CER development,
- cost/benefit analysis, and
- decision analysis.

Each of these can play a role in the methods discussed above in that they can be used to estimate the value of parameters needed in the other methods. For instance one might develop a CER to estimate a particular cost element needed in PERT or in a WBS Simulation.

CER development usually centers around an application of regression analysis to determine a representation of the cost of something (a system, subsystem, component, etc.) as a function of technical parameters such as weight, power input, peformance, etc. Since regression is used in CER development, there is a rich statistical theory that can be brought to bear to determine confidence intervals for the estimates made.

Cost/benefit analysis generally results from a quantification of both the cost of a particular item or program element and

its associated benefit. A comparison of those two quantities can provide a way to evaluate the wisdom of undertaking an activity. The comparison can be made in any number of ways. In particular, if one takes the ratio of cost-to-benefit, then values of that ratio above a pre-selected threshold would signal a decision against the activity, and values of the ratio below the threshold would favor a decision to perform the activity.

Decision analysis is a general category of analysis that includes methods in the areas of stochastic processes, utility theory, and game theory, and draws on such fields as probability, statistics, optimization, and economics for specific techniques. The general approach often described in this area, although many could be described, is one of analyzing a sequence of events. The events are generally hierarchical, i.e., they are ordered and some subsets of events occur only based on the outcomes of proceding events. When probabilities of occurrence are associated with each event and the events are independent, one can easily determine the probability of any feasible sequence of the events. That information can then be used for decision making. For instance, suppose a system is being prepared for a milestone and a decision must be made to proceed on one of two schedules. The above scheme could be used to determine the probability of success of each schedule and the selection could be made with that probability as one input. One would, of course, include other information, such as the cost of each schedule.

DATA REQUIREMENTS

Many of the techniques that are used by Program Offices require significant amounts of data to execute. That is especially true of the scheduling tecniques. Apart from the shear magnitude of the data requirement, some types of data elements can be difficult to generate. That is especially true of data elements that represent probabilities. A number of techniques have been developed to assist in this area when experimentation is infeasible or too costly or when sufficient "hard data" is not available.

For instance, in lieu of fully specified probability distributions, PERT uses a beta distribution and estimates of the optimistic (t_a), most likely (t_b), and pessimistic (t_c) time to complete an activity. The expected time (t_e) for the completion of that activity is then given by the formula:

$$t_e = \frac{t_a + 4t_b + t_c}{6}.$$

Another method for generating probability distributions is the Delphi technique. There, expert opinion is gathered and through a structured questionnaire, one can estimate the probability of events by polling experts in the field. Simulation is yet another technique that can be used to generate needed probabilities. However, this method can itself require considerable effort to utilize due to its own requirements for data and programming.

Often, historical data can be used to project future values of parameters. Regression and time series analyses are often-used analytical techniques for this purpose. Extrapolation along a regression line when time is the independent variable can be a useful tool, when coupled with analysis of the confidence intervals of the estimate. When there is seasonality in the historical data, i.e., when there are several distinguishable trends at play, time series techniques (e.g., the Box-Jenkins method) should be used.

There are many factors to consider in applying risk analysis techniques. The application of the techniques themselves is complicated by the complexity and implications of Program Office planning and decision-making, and by the validity of the data available to support the analysis. Therefore the analyses must be done carefully; they must be well-planned, accurately executed, and systematically evaluated.

References for each of the techniques discussed can be found in Appendix A.

PART V. PLANNING, MANAGEMENT, AND ACQUISITION STRATEGIES

- Chapter 11. Suggestions on Strategies

PART V. PLANNING, MANAGEMENT, AND ACQUISITION STRATEGIES

The final part of this handbook addresses the various strategies the Program Manager and his staff can adopt for balancing materiel readiness risks and concurrency in acquisitions. These suggestions are contained in Chapter 11, **SUGGESTIONS ON STRATEGIES**, the final chapter in this handbook.

CHAPTER 11. SUGGESTIONS ON STRATEGIES

- Planning Strategies
- Management Strategies
- Acquisition Strategies

CHAPTER 11. SUGGESTIONS ON STRATEGIES

The ultimate goal of the PM in balancing materiel readiness risks and concurrency in an acquisition is to be able to produce a system within the given cost, schedule, performance and supportability constraints. The approach for accomplishing these goals is laid out initially in the program's acquisition strategy. The acquisition strategy is the guidance document identifying the program's priorities.

In addition to developing the formal acquisition strategy, we suggest that the PM formulate associated strategies for planning and management. These strategies elaborate on the acquisition strategy concepts and are intended to clearly communicate to the PO staff and contractors the PM's intentions for implementing the program priorities.

This chapter contains general suggestions for developing each of these strategies.

PLANNING STRATEGIES

In programs with concurrency, the PM, Program Control Directorate staff, functional area managers, and contractors must all be committed to actively addressing the planning implications of concurrency. Many of these have been discussed in Chapters 2, 7 and 8.

The primary element of the planning strategy should be the recognition that tasks and activities should be broken down (decomposed) to the <u>lowest</u> level of effective detail. Too often

in programs, activities are planned and monitored at such an aggregate level that vital information is not influential in decision making. The trade off, however, must be made between too much and too little data, since either extreme produces the same effect, the masking of vital details.

Using the priorities set out in the acquisition strategy, the PM and functional managers should translate these goals into specific functional requirements and determine the specific form, detail and process for tracking, monitoring, and reporting on the status of these priority-related activities.

In LSA planning, logisticians frequently use a step-by-step program sequencing planning approach. This approach is implemented using descending levels of detail in each of the ILS elements. It consists of interpreting a backward and forward sequence of activities, (i.e., "If I have to be able to have this, then this must be done first.") Whatever the device used, the staff must have a clear understanding of the program priorities, with sufficient direction to be able to make decisions.

The planning strategy must also incorporate a clear determination on the interactions among the functional groups for supporting these priorities. The various discussions of the readiness-related activities in this handbook show that the efforts of many functional areas are involved. These interrelationships and dependencies must be explicitly recognized and incorporated in any planning for achieving the goal of high system readiness.

Finally, the planning strategy must recognize the need to plan for contingencies. The following statement has been made regarding the development of schedules, however, it applies for all planning functions.

"When developing schedules, the following assumption has to be made: Nothing works right the first time; everything goes wrong, and everybody makes mistakes."1/

Once again, a balance must be reached between planning for every possible incidence of Murphy's Law striking, and planning with unrealistic optimism. The planning strategy should recognize the high risk areas of the program and encourage the development of plans for constructing recovery programs, should the need arise. While many managers reject the idea of planning for disasters, a civil defense attitude as part of a planning strategy may encourage openness in dealing with the inherent problems of balancing materiel readiness and concurrency.

MANAGEMENT STRATEGIES

The management strategy is the statement of the philosophy and approach that the PO intends to apply and expects to see implemented throughout the program. This strategy relates to how the various groups involved in the program will interact, the hierarchy of authority, and the processes and procedures that will be used to manage for progress while minimizing risks.

1/ Godden, Forrest L., Jr., "Scheduling for Program Management: How and Why," Concepts, Volume 4, Number 4, Defense Systems Management College, Autumn 1981.

A key act of the management strategy is the management control system which will be used to communicate the status of the activities. The following is a suggested set of criteria for such a system:[2/]

- furnish timely, pertinent, adequate, and accurate information;
- ensure that decisions are made well in advance of performance (it must force effective planning before initiation of the program);
- be flexible to accommodate necessary changes;
- be economical in operation;
- be relatively simple in operation and understandable by all users of the system, both Government and contractor personnel;
- permit management by exception;
- provide a basis to evaluate alternative courses of action prior to initiation;
- forecast trouble areas as well as indicate current deficiencies; and
- indicate significant differences between planned and actual performances.

In addition to these, the management system must have an effective "diagnostic" system in it: fault isoloation with an associated corrective action process. There are many successfully managed programs, and a feature they all seem to share is a management control system that is:

- sensitive to the critical and high-risk areas;
- detailed enough to respond to the hidden problems;

2/ Army Programs: Program Evaluation and Review Techique (PERT), AMCP No. 11-6, Army Materiel Command, 3 January 1972.

- frequently exercised enough to make all participants aware of its operation;
- progress-oriented so as to not allow for activities to get stalled in a closed loop of inactivity; and
- organized to allow for consistent, compatible levels of detail to be developed and communicated throughout the program.

If these sound like basic management practices, it should not be surprising. Well managed programs do not just happen, they must be deliberately constructed for good and effective management. The problems of balancing materiel readiness and concurrency are such that such a management strategy is virtually mandatory.

ACQUISITION STRATEGIES

Of all of the strategies the PM must develop, the acquisition strategy is probably the most well known. This strategy is a basic requirement in program management and must be approved through the chain of command.

The acquisition strategy is, among other things, the statement of program priorities. As such it is the pivotal document for clearly stating the program goals, particularly regarding readiness. It is also the vehicle which can be effectively used for expressing the intended applications of concurrency, and the circumstances requiring this strategy. If the use of concurrency is intended as a planning, management, or acquisition strategy, it should be clearly stated in the acquisition strategy.

The acquisition strategy should also contain a clear and definitive exploration of how the concurrency will be used in conjunction with achieving the program's readiness goals. This means including clear statements of how these goals will be represented in the major areas of program activities. The following is a suggested list of the activities that should be discussed:[3/]

- Contracting:
  - R&M requirements,
  - mission profile establishment,
  - life profile establishment,
  - R&M failure definition,
  - incentives,
  - source selection criteria, and
  - LCC consideration;
- Management:
  - planning, control and emphasis of Government and contractors,
  - monitoring and control of subcontractors and supplies, and
  - engineering change process;
- Design:
  - development of design requirements,
  - design alternative studies,
  - design evaluation analyses,
  - parts and materiel selection and control,

3/ IDA/OSD Reliability and Maintenance Study, Volume III, Case Study Analysis, Institute for Defense Analyses, November 1983.

- derating criteria,
- thermal and packaging criteria,
- computer aided design,
- testability analysis, and
- testability verification and testing;

- Production:
  - environmental stress screening (ESS), and
  - failure reporting, analysis and corrective action systems; and

- Test and Evaluation:
  - design-limited qualification testing,
  - reliability growth testing,
  - demonstration testing,
  - operational test and evaluation, and
  - in-service assessment.

The suggestions presented in this chapter are intended to raise thoughts in the reader's mind regarding the interactions that need to take place between management and technical functions, and to sensitize managers to the readiness implications of concurrency decisions.

APPENDIX A

REFERENCES

APPENDIX A. REFERENCES

This appendix contains lists of instructions, directives, regulations, manuals, standards, and studies which the Program Manager and his staff should review. The lists are organized according to topic, with the same reference possibly appearing under several headings.

This is not intended to be a definitive list of <u>all</u> the relevant documents of which the PM should be aware. Rather, it is an initial listing which should be used as the basis for pursuing research on additional sources of information. These lists have been constructed from a variety of sources, and it is possible that some of these documents are no longer available, may be in revision, or may have already been revised. The reader should be aware of this, and use these lists as a guide.

ORGANIZATIONAL RELATIONSHIPS AND RESPONSIBILITIES

AFR 170-3, Financial Management of the Security Assistance Program.

AFR 800-2, Acquisition Program Management.

AFR 800-8, Integrated Logistics Support (ILS) Program.

AFLCR 800-9, Management of DPML/ILSOs.

AFLCR 400-1, Logistics Management Policy.

DOD 5105.38M, The Military Assistance and Sales Manual.

STATEMENT OF OPERATIONAL NEED (SON)/MISSION ELEMENT NEED STATEMENTS (MENS)

AFR 57-1, Statement of Operational Need (SON).

DOD 5105.38M, The Military Assistance and Sales Manual.

AFR 400-3, Foreign Military Sales.

AFLC PROGRAM ACTION DIRECTIVE (PAD) AND AFSC PROGRAM DIRECTION

AFR 57-4, Modification Program Approval.

AFR 400-3, Foreign Military Sales; AFLC Supplement 1.

AFR 800-2, Acquisition Program Management, as supplemented.

AFSCR 27-1, Program Direction.

AFLCR/AFSCR 57-3, Class V. Modification Management.

AFLCR 57-21, Modification Program Approval.

AFLCR 400-1, Logistics Management Policy.

PLANNING, PROGRAMMING, BUDGETING FOR ACQUISITION LOGISTICS

AFM 172-1, USAF Budget Manual.

AFP 172-4, The Air Force Budget.

AFLCR 27-3, The AFLC Program Objective Memorandum (POM).

AFLCR 400-1, Logistics Management Policy.

United States Air Force Long Range Capabilities Objective (LRCO).

The Air Force Planning Guide (AFPG).

MANPOWER PLANNING AND ASSIGNMENTS

AFM 26-1, Manpower Policies and Procedures.

AFR 26-2, Organization Policy and Guidance.

AFLCR 800-9, Management of DPMLs/ILSOs.

PROGRAM MANAGEMENT PLAN (PMP)

AFR 800-2, Acquisition Program Management.

AFR 800-8, Integrated Logistics Support (ILS) Program for Systems and Equipment.

AFSCP 800-3, A Guide for Program Management.

INTEGRATED LOGISTIC SUPPORT PLANS (ILSP)

AFR 800-8, Integrated Logistics Support (ILS) Program, as supplemented.

INTEGRATED SUPPORT PLAN (ISP)

AFLCR/AFSCR 800-24, Standard Integrated Support Management System.

LOGISTIC SUPPORT ANALYSIS (LSA)

MIL-STD-1388-1A, Logistic Support Analysis.

MIL-STD-1388-2, Logistic Support Analysis Data Element Definitions.

MIL-STD-499, Engineering Management.

AFSCM/AFLCM 800-4, Optimum Repair Level Analysis.

CONTRACTING

DOD 4105.59H, DOD Directory of Contract Administration Services Components.

DODI 4105.59, DOD Plant Cognizance Program.

DODD 4105.62, Selection of Contractual Sources for Major Defense Systems.

DODI 4105.64, Technical Representation at Contractors' Facilities.

DODD 5000.1, Major System Acquisition.

DODI 5000.2, System Acquisition Process.

DAR (ASPR) 1-406, Contract Administration Functions.

DAR (ASPR) 1-2100.4, Acquisition Planning.

AFSC DAR (ASPR) Supplement (C6), 20-703, Retention of Contract Administration by the Purchasing Office.

AFR 70-15, Source Selection Policy and Procedures.

AFSCR 80-15, R&D Source Selection, Policy and Guidance.

AFSCR 70-7, AFSC Solicitation Review Panel.

AFSCR 70-2, Business Strategy Panel.

DAR (ASPR) 3-501, Preparation of Request for Proposals or Request for Quotations.

INTERIM CONTRACTOR SUPPORT (ICS)

AFR 800-21, Interim Contractor Support for Systems and Equipment

AFM 172-1, USAF Budget Manual.

MIL-STD-499, Engineering Management.

MIL-STD-1388-1A, Logistic Support Analysis.

MIL-STD-1388-2, Logistic Support Analysis, Data Element Definitions.

AFR 66-7, Depot Level Maintenance Production.

WORK BREAKDOWN STRUCTURE (WBS)

MIL-STD-881A, Work Breakdown Structure (WBS) for Defense Material Items.

AFR 800-17, Work Breakdown Structures (WBS) for Defense Material Items.

AFLCP-AFSCP 173-5, Cost/Schedule Control Systems Criteria (Joint Implementation Guide).

RELIABILITY AND MAINTAINABILITY (R&M)

AFR 80-5, Air Force Reliability and Maintainability Program.

MIL-STD-470, Reliability Program for Systems and Equipment, Development, and Production.

MIL-STD-470, Maintainability Program Requirement (for System and Equipment).

DODD 5000.1, Major System Acquisitions.

DODI 5000.2, Major System Acquisition Procedures.

SURVIVABILITY

AFR 80-38, Management of the Air Force Survivability Program. AFSC Supplement 1.

The Management of Nuclear Hardened Parts, Final Report, AFALD/AQI Project 77-14.

Hardness Awareness Seminar, TR-PTE/SV-78-101.

B-1 Hardness Assurance Guidelines, ASD-TR-75-35.

Nuclear Hardness Assurance Guidelines for Systems with Moderate Requirements, AFWL-TR-76-147.

Missile-X Program Logistics Element Management Plan for Nuclear Hardness and Survivability Interface LEM, 15 Aug. 77, SAMSO/MNL, AFSC.

AFR 800-8, Integrated Logistics Support (ILS) Program, as supplemented.

LIFE CYCLE COST (LCC) MANAGEMENT PROGRAM

DODD 5000-28, Design to Cost.

AFR 66-14, Equipment Maintenance Policies, Objectives, and Responsibilities.

AFR 80-5, Air Force Reliability and Maintainability Program.

AFR 800-11, Life Cycle Cost Management Program.

AFLCP/AFSCP 800-19, Joint Design-To-Cost Guide.

AFP 173-13, USAF Cost and Planning Factors Guide.

MIL-STD-1388-1A, Logistic Support Analysis.

REPORTS

AFM 67-1, Volume IX, Chapter 7, USAF Supply Manual.

AFM 177-112, International Accounting Transactions.

AFR 400-3/AFLC Sup 1, Foreign Military Sales.

AFLCR 800-25, Command Review of Systems Acquisition Programs.

PROVISIONING STRATEGY

AFR 800-24, Parts Control Program (PCP).

AFR 800-21, Interim Contractor Support for Systems and Equipment.

AFLCR 57-27, Initial Requirements Determination.

MIL-STD-965, Parts Control Program.

SUPPLY SUPPORT

AFR 57-6, DOD High Dollar Spare Parts Breakout Program.

AFR 65-2, Provisioning of End Items of Materiel.

AFR 66-1, Maintenance Management.

AFR 67-47, Phased Provisioning.

AFR 80-5, Air Force Reliability and Maintainability Program.

AFR 800-21, Interim Contractor Support for Systems Equipment.

AFR 800-24, Parts Control Program (PCP).

AFR 800-26, Spares Acquisition Integrated with Production (SAIP).

AFLCR 57-4, Recoverable Item Requirements Systems (D041).

AFLCR 57-27, Initial Requirements Determination.

AFLCR 65-5, Air Force Provisioning Policies and Procedures.

AFLCR 67-7, Stock Fund Initial Spares Requirements.

AFLCM/AFSCM 800-4, Optimum Repair-Level Analysis (ORLA).

AFLCP 57-13, Recoverable Inventory Control Using MOD-METRIC.

MIL-STD-965, Parts Control Program.

MIL-STD-1517, Phased Provisioning.

MIL-STD-1552, Provisioning Technical Documentation.

MIL-STD-1561, Provisioning Procedures.

MAINTENANCE ACTIVATION PLANNING

AFR 8-2, Air Force Technical Order System.

AFR 50-9, Special Training.

AFR 66-14, Equipment Maintenance Policies, Objectives, and Responsibilities.

AFR 86-1, Programming Civil Engineer Resources.

AFR 89-1, Design and Construction Management.

AFM 172-1, USAF Budget Manual.

AFR 800-3, Engineering for Defense Systems.

AFR 800-8, Integrated Logistics Support (ILS) Program.

AFR 800-12, Acquisition of Support Equipment.

AFR 800-21, Interim Contractor Support for Systems and Equipment.

AFLCR 65-14, Policy and Procedural Guidance for Interservice of Depot Level Maintenance.

AFLCR 66-17, Depot Maintenance Support Planning.

AFLCR/AFSCR 66-36, Aeronautical Depot Maintenance Industrial Technology (ADMIT).

AFLCR 66-75, Depot Maintenance Source of Repair (SOR) Decision Tree Analysis.

AFSCR/AFLCR 67-17, Item Name Assignment Procedures for Type Designated Equipment.

AFLCR 523-1, Mission Assignment Policy.

AFLCR 523-3, AFLC Mission Assignment.

AFSCP 800-3, A Guide for Program Management.

AFSCR 800-10, AFSC Lessons Learned Program.

AFSCR/AFLCR 800-11, Site Activation/Alteration Task Forces (SATAF).

AFLCR/AFSCR 800-24, Standard Integrated Support Management System.

AFLCR/AFSCR 800-30, Maintenance Interservicing New Start Identification.

MIL-STD-155, Joint Photographic Type Designation System.

MIL-STD-196, Joint Electronics Type Designation System.

MIL-STD-875, Type Designation for Aeronautical and Support Equipment.

MIL-STD-1388-1A, Logistic Support Analysis.

H2-1, 2, and 3, DOD Cataloging Handbooks.

DEPOT MAINTENANCE INTERSERVICING (DMI)

AFLCR/AFSCR 800-24, Standard Integrated Support Management System.

AFLCR/AFSCR 800-30, Depot Maintenance Interservicing.

GOVERNMENT-FURNISHED EQUIPMENT (GFE)

AFR 800-22, CFE vs GFE Selection Process.

AFSCR/AFLCR 800-31, Government-Furnished Equipment/Contractor-Furnished Equipment (GFE/CFE) Selection Process, GFE Acquisition, and GFE Management.

SUPPORT EQUIPMENT (SE)

AFR 8-2, Air Force Technical Order System.

AFR 66-14, Equipment Maintenance Policies, Objectives, and Responsibilities.

AFR 80-14, Test and Evaluation.

AFR 800-14, Transfer of Program Management Responsibility.

AFR 800-12, Acquisition of Support Equipment.

AFR 800-14, Vol I, Management of Computer Resources in Systems.

AFR 66-1, Maintenance Management.

AFM 67-1, Vol I, Part 1, Chapter 6; Vol III, Part 7; Vol IV, Part 1, Chapter 28 (Table of Allowance System).

AFLCR 65-5 (Chapter 41), AF Provisioning Policies and Procedures.

AFLCR 66-37, Management of Automated Test Systems.

AFLCR 67-2, USAF Equipment Allowance System.

AFLCR 67-14, AF Equipment Allowance Management Program.

AFSCR/AFLCR 800-5, AGE Acquisition Management.

AFSCR/AFLCR 800-24, Standard Integrated Support Management System (SISMS) (Chapter 5, Support Equipment).

AFLCM 57-2, Computation of Requirements for Equipment Type Items.

AFAD 71-785, AGE Identification, Selection, Acquisition, and Provisioning Document for USAF Contracts.

MIL-STD-1513, Trade Studies, Criteria for Selection of Avionics Test Support Systems.

MIL-STD-1519, Test Requirements Documents.

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Sec III, Estimated Data Prices (DD Form 1423).

Sec IV, Scientific and Technical Reports.

Sec VII, Rights in Data; Deferred Delivery of Technical Data; Technical Withholding of Payment; Deferred Ordering of Technical Data; Requirements for Data; Warranty of Technical Data.

Sec IX, Rights in Technical and Other Data and Copyrights; Acquisition of Technical Data.

Sec XVI, Contract Data Requirements List (DD Form 1423); Management Systems Summary List (DD Form 1660); Data Item Description (DD Form 1664).

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TO 00-20-4, Configuration Management Systems.

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MIL-STD-130, Identification and Marking of US Military Property.

DOD-D-1000B, Drawing, Engineering and Associated Lists.

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APPENDIX B

GLOSSARY OF TERMS AND ABBREVIATIONS

APPENDIX B. GLOSSARY OF TERMS AND ABBREVIATIONS

This appendix contains two parts. The first is a glossary of terms frequently used in acquisition and logistics (pages B-1 to B-11). These terms are briefly defined with a pertinent source of additional information noted after the definition. Following these definitions is a list of acronyms used in acquisition and logistics (pages B-12 to B-16).

GLOSSARY OF TERMS

Air Force-Designated Acquisition Program (AFDAP). A system acquisition program not qualifying as a major system acquisition, but determined by the SAF to be of such importance and priority that it requires special management attention and Secretarial-level milestone decisions. (AFR 80-14)

Air Force Systems Acquisition Review Council (AFSARC). The senior Air Force advisory council for system acquisition. Its membership includes the Under Secretary of the Air Force, the Assistant Secretaries, the Vice Chief of Staff, and designated Deputy Chiefs of Staff. The AFSARC reviews: major programs as part of the SECDEF milestone decision process; other designated acquisition programs before decisions by the SAF; and, in special instances, other acquisition programs when the decision to be made is of such importance that is requires SAF attention. (AFR 800-2)

Automatic Test Equipment (ATE). ATE is a generic term for equipment (separate or built in) satisfying a test function (diagnostic or condition indicating) and possessing an automatic capability. In this sense, ATE can be either a part of the mission equipment or it can be a part of support equipment. (Also, see MIL-STD-1309.) (AFR 800-12)

Ceiling Price. A negotiated amount that specifies the maximum liability of the Government for a given acquisition.

Change Order. A written order signed by the contracting officer, directing the contractor to make changes that the Changes clause of the contact authorizes the contracting office to make without the consent of the contractor. (Defense Acquisition Regulation Manual (DARM) No. 1)

Competitive Negotiation. A negotiated acquisition that (1) is initiated by a Request for Proposals, which sets out the Government's requirements and the criteria for evaluation of offers, (2) contemplates the submission of timely proposals by the maximum number of possible offerors, (3) usually provides discussion with those offerors found to be within the competitive range, and (4) concludes with the award of a contract to the one offeror whose offer, price and other factors considered, is most advantageous to the Government. (DARM No. 1)

Computer Program. A series of instructions of statements in a form acceptable to an electronic computer, designed to cause the computer to execute an operation or operations. (AFR 800-14, Vol. II)

Computer Program Identification Number (CPIN). A variable, alphanumeric identifier used to provide unique identification, control, and management of Embedded Computer Systems (ECS) software in the Air Force. (AFLCR 800-21)

Computer Resources. The totality of computer equipment, computer programs, associated documentation, contractual services, personnel and supplies. (AFR 800-14, Vol. I)

Concept Exploration Phase. The identification and exploration of alternative solutions or solution concepts to satisfy a validated need, usually through the use of contracts with competent industry and educational institutions. This phase requires the active involvement of all participating commands to identify the candidate solutions and their characteristics. One or more of the selected candidate solutions are then approved for entry into the Demonstration and Validation phase.

Configuration (Change) Control Board (CCB). A board composed of representatives from program/project functional areas such as engineering, configuration management, contracting, manufacturing, test and logistic support, training activities and using/supporting organizations. This board approves or disapproves proposed change requests. (AFSCP 800-7)

Configuration Item/Computer Program Configuration Item (CI/CPCI). An aggregation of hardware/computer programs or any of its discrete portions, which satisfies an end-use function and is designated by the Government for configuration management. (AFR 65-3)

Configuration Management (CM). A discipline applying technical and administrative direction and surveillance to (1) identify and document the functional and physical characteristics of a configuration item, (2) control changes to those characteristics, and (3) record and report change processing and implementation status. It includes configuration identification, control, status accounting and audits. (AFSCP 800-7)

Constructive Change. During contract performance, an oral or written act or ommission by the contracting officer or other authorized Government official, which is of such a nature that it is construed to have the same effect as a written change order. (DARM No. 1)

Contract Data Requirements List. A listing of data requirements authorized and made a part of the contract on DD Form 1423, "Contract Data Requirements List," or mechanical equivalent. (AFSCM/AFLCM 310-1)

Contractor Furnished Equipment. Property, other than Government furnished, used by the contractor in the performance of a contract. (AFSCM 27-1)

Decision Coordinating Paper (DCP). The principal document to record essential system program information for use in support of the Secretary of Defense decision-making process at Milestones, I, II and III. (DODD 5000.2)

Defense Acquisition Executive. The principal advisor and staff assistant to the Secretary of Defense and the focal point in OSD for system acquisitions. (DODD 5000.1)

Defense Acquisition Regulation. Uniform policies for the Department of Defense relating to the acquisition of supplies and services under the authority of Title 10, United States Code, Chapter 137. Formerly called the Armed Services Procurement Regulation. (AR 320-5)

Defense Systems Acquisition Review Council (DSARC). An advisory council established by and functioning for the Secretary of Defense (SECDEF) to apprise the SECDEF of the program status and readiness of a major defense system prior to proceeding to the next phase in the acquisition process. (AFR 80-14)

Definitized Agreement. A contract that has been signed by both the contractor and the Government. The term usually implies that a price has been negotiated and has been reflected in the contract.

Demostration and Validation Phase. The period when selected candidate solutions are refined through extensive study and analyses; hardware development, if appropriate; tests; and evaluations. The objective is to validate one or more of the selected solutions and give a basis for deciding whether to proceed into Full-Scale Development. (AFR 800-2)

Deputy Program Manager of Logistics (DPML). The logistics representative for major programs at the Program Office. He is directly responsible to the PM for all logistic tasks. He ensures that logistic participation and support capabilities agree with program objectives and that logistics support requirements are reflected in the system design. (AFSCP 800-3)

Determination and Finding. A formal document that records the decision of a contracting officer and higher approval, if necessary. Determination and Findings are used to secure approval to negotiate rather than advertise, to use a cost type contract, and to exercise an option.

Development Testing and Evaluation (DT&E). That testing and evaluation used to measure progress, verify accomplishment of development objectives, and to determine if theories, techniques, and materiel are practicable; and if systems or items under development are technically sound, reliable, safe, and satisfy specifications. (AFM 11-1)

Follow-on Operational Test and Evaluation (FOT&E). The second phase of operational test and evaluation conducted on production items in an operational environment. It is conducted to verify operational effectiveness and operational suitability and to provide information on organization, personnel requirements, doctrine and tactics, and assess whether production techniques have affected system performance or operational suitability as determined during initial operational test and evaluation. (AFM 11-1)

Formal Advertising. One of the major methods of acquisition preferred by law when it is feasible and practicable to employ it. It is used in one of two forms, as appropriate to the requirement: conventional formal advertising and two-step formal advertising. The first involves the acquisition of well-defined items requiring the submission of technical proposals prior to the submission of prices. In both forms, award is made to the responsible bidder whose bid, conforming to the invitation for bids, will be most advantageous to the Government, price nd other factors considered. (DARM No. 1)

Full-Scale Development Phase. The period when the system and the principal items necessary for its support are designed, fabricated, tested, and evaluated. The intended output is, as a minimum: a preproduction system that closely approximates the final product; the documentation needed to enter the production phase; and the test results that show the product will meet the requirements. This phase includes the acquisition of long lead production items and limited production for OT&E. (AFR 800-2)

Government Furnished Equipment. Separable equipment and components of a total system acquired by the Navy and supplied to the system prime contractor for integrating into the system. (NAVMAT P-4215)

Government Furnished Property. Property in the possession of or acquired by the Government and delivered or otherwise made available to a contractor for use in accomplishing a contract. (AFSCM 57-2)

Head of Acquiring Activity. The chief, commander, or other official in charge of an acquiring activity. Acquiring activities include such commands as Air Force Systems Command, Air Force Logistics Command, Tactical Air Command, and others. (DAR)

Implementing Command. The command (normally AFSC) charged with responsibility for acquiring systems and equipment for the Air Force inventory. (AFR 800-4)

Initial Operational Test and Evaluation (IOT&E). The first phase of operational test and evaluation conducted on preproduction items, prototypes, or pilot production items and normally completed prior to the first major production decision. It is conducted to provide a valid estimate of a system's operational effectiveness and operational suitability prior to the first major production decision. (AFM 11-1)

Integrated Logistics Support (ILS). A unified and iterative approach to the management and technical activities necessary to: (1) cause support considerations to influence both requirements and design; (2) define support requirements that are optimally related to the design and to each other; (3) acquire the required support; and (4) provide for the required support in the operational phase at minimum cost. (AFR 800-8)

Integrated Logistics Support Manager (ILSM). An experienced logistician who is assigned to manage ILS for programs not designated as major programs. (AFR 800-8)

Integrated Logistics Support Plan (ILSP). An Air Force management plan developed and used by the program manager and the DPML or ILSM, to manage the ILS process. This includes the horizontal integration of the ILS elements (that is, with each other), as well as their vertical integration into the various aspects of program planning, engineering, designing, testing, evaluating, and during production and operation. It also includes the integration of support elements with the mission elements of a system throughout its life cycle, and is updated as the program evolves. The ILSP is a part of the Program Management Plan (PMP) and, when approved, becomes directive on all participating agencies. (AFR 800-8)

Invitation for Bids. The soliciation document used in conventional formal advertising and in the second step of two-step formal advertising. (DARM No. 1)

Item Manager (IM). The AFLC ALC (or other service or agency) assigned the management responsibility for commodity-type items by Federal Supply Class. (AFSCP 800-7)

Learning Curve. A tool of calculation used primarily to project resource requirements, in terms of direct manufacturing labor hours or the quantity of material (for this purpose, usually referred to as an improvement curve) required for a production run. Used interchangeably with the term "improvement curve," the concept of a learner's curve was adopted from the observation that individuals who perform repetitive tasks exhibit a rate of improvement due to increased manual dexterity. Learning or improvement curve theories include the following:

- The Boeing or unit curve theory: As the total quantity of units produced doubles, the cost per unit decreases by some constant percentage (the rate of learning).

- The Northrup or cumulative average theory: As the total quantity of units doubles, the average cost per unit decreases by some constant percentage (the rate of learning). (DARM No. 1)

Letter of Offer/Acceptance (LOA). A Document, KDD 1513, that records the offer of the United States to sell and the foreign government's agreement to buy a given article or service.

Life Cycle Cost (LCC). The total cost of an item or system over its full life. It includes the cost of acquisition, ownership (operation, maintenance, support, etc.) and, where applicable, disposal. To be meaningful, an expression of life cycle cost must be placed in context with the cost elements included, period of time covered, assumptions and conditions applied, and whether it is intended as a relative comparison or absolute expression of expected cost effects. (AFR 800-11)

Major System Acquisition. A system acquisition program designated by the Secretary of Defense to be of such importance and priority as to require special management attention. (DODD 5000.1)

Milestone 0 Decision. Approval of MENS and authorization to proceed into Phase 0--Concept Exploration--which includes solicitation, evaluation and competitive exploration of alternative system concepts. Approval to proceed with Concept Exploration also means that the Secretary of Defense intends to satisfy the need. (DODD 5000.1)

Milestone I Decision. Selection of alternatives and authorization to proceed into Phase I--Demonstration and Validation. (DODD 5000.1)

Milestone II Decision. Selection of alternative(s) and authorization to proceed into Phase II-Full-Scale Development--which includes limited production for operational test and evaluation. Approval to proceed with Full-Scale Development also means that the Secretary of Defense intends to deploy the system. (DODD 5000.1)

Milestone III Decision. Authorization to proceed into Phase III--Production and Deployment. (DODD 5000.1)

Mission Area Analysis. Continuous analysis of assigned mission responsibilities in several mission areas, to identify deficiencies in the current and projected capabilities, to meet essential needs, and to identify opportunities for the enhancement of capability through more effective systems and less costly methods. (AFR 57-1)

Mission Element Need Statement (MENS). A statement prepared by DOD Component to identify and support the need for a new or improved mission capability. The mission need may be the result of a projected deficiency or obsolesence in existing systems, a technological opportunity, or an opportunity to reduce operating cost. The MENS is submitted to the Secretary of Defense for a Milestone 0 decision. (DODD 5000.2)

Not-To-Exceed Price. An amount stipulated by the contractor for which he will do a defined amount of work. Not-to-exceed prices are typically submitted as part of Class I engineering change proposals. If the contracting officer decides to order the contractor to make the change by means of a change order, the not-to-exceed price is stipulated in the change order and represents the maximum amount the contractor can collect for performing the work.

Operational Test and Evaluation (OT&E). Testing and evaluation (divided into initial operational test and evaluation and follow-on operational environment as possible to estimate the prospective systems military utility, operational effectiveness and operational suitability. (AFM 11-1)

Participating Command. A command or agency designated by HQ USAF to support and advise the PM. A supporting command is also a participating command. (AFR 800-2)

Price Negotiation Memorandum. The document that relates the story of the negotiation. It is first a sales document that establishes the reasonableness of the agreement reached with the successful offeror. Second, it is the permanent record of the decisions the negotiator made in establishing that the price was fair and reasonable. Called the PNM. (DARM No. 1)

Product Division. Those organizational bodies within AFSC responsible for systems acquisition. These bodies are ASD, ESD, AD, BMD, and SD.

Production and Deployment Phase.

(1) The period from production approval until the last system is delivered and accepted. The objective is to efficiently produce and deliver effective and supportable systems to the operating units. This includes the production of all principal and support equipment.

(2) Deployment. The period encompassing the process of uniting facilities, hardware and software, personnel, and procedural publications; and delivering an acceptable integrated system to the using and supporting commands. This overlaps the production phase. (AFR 800-2)

Program Assessment Review. Quarterly status review of each major system program. Normally, a 30 minute presentation by the program manager. Program assessment review presentations are made to the Commander, AFSC. (AFSCP 800-3)

Program Management Directive (PMD). The HQ USAF document that directs the implementing and participating commands and satisfies documentation requirements. It is used during the entire acquisition life cycle to state requirements and request studies, as well as initiate, approve, transfer, modify, or terminate programs. The content of the PMD is tailored to the needs of each program. (AFR 800-2)

Program Management Plan (PMP). The document developed by the PM, with assistance from the participating commands. It shows the program objectives as well as the integrated time-phased activities and resources required to complete the task specified in the PMD. The PMP is tailored to the needs of each program, is approved and issued by the PM, and is directive on all participating commands. (AFR 800-2)

Program Management Responsibility Transfer (PMRT). The transfer of program management responsibility for a system (by series), or equipment (by designation), from the implementing command to the supporting command. PMRT includes transfer of engineering responsibility. (AFR 800-4)

Program Manager (PM). The single Air Force manager (system program director, program/project manager, or system/item manager) during any specific phase of the acquisition life cycle. (AFR 800-2)

Program Office (PO). The office of the PM and the single point of contact with industry, Government agencies, and other activities participating in the system acquisition process. It is the office the program manager sets up for the acquisition of systems, subsystems, equipment, munitions, or modifications to them. (AFR 800-2)

Progress Payment. A payment made as work progresses under a contract on the basis of percentage of completion accomplished, or for work performed at a particular stage of completion. (DARM No. 1)

Purchase Request. An authenticated document prepared by a purchasing office that stipulates the quantities and delivery dates of supplies or services. Purchase requests authorize the contracting officer to acquire the items.

Qualification T&E (QT&E). T&E performed in lieu of DT&E on programs for which there is no research, development, test and evaluation (RDT&E) funding. (AFR 80-14)

<u>Qualification OT&E (QOT&E)</u>. T&E performed in lieu of IOT&E on programs for which there is no research, development, test and evaluation (RDT&E) funding. (AFR 80-14)

<u>Request for Proposal</u>. The solicited contract between the Air Force and the contractor on a contemplated acquisition. It is the medium by which a contractor is introduced to the job desired by conveying a complete understanding of the work to be performed and to determine the capability and price of the contractor's efforts. RFPs contain language, terms, and conditions necessary to obtain information from prospective bidders. (AFSCM 27-1)

<u>Secretary of Defense Decision Memorandum (SDDM)</u>. Documents each milestone decision, establishes program goals and thresholds, reaffirms established needs and program objectives, authorizes exceptions to acquisition policy (when appropriate), and provides the direction and guidance to OSD, OJCS, and the DOD Component for the next phase of acquisition. (DOD 5000.1)

<u>Share Ratio</u>. A formula which represents a joint responsibility for ultimate costs that is translated into a sharing in any dollar difference between target and final costs. For example, a 70/30 share ratio means 30 cents of every dollar is the contractor's responsibility. (DARM No. 1)

<u>Site Activation/Alteration Task Force (SATAF)</u>. PM-established working group composed of Program Office and participating organization personnel to ensure proper deployment planning (including intergrated logistics, training, and operational support aspects) and scheduling of deployment eventsand to ensure that such events are completed as scheduled. (AFSCP 800-3)

<u>Sole Source</u>. Characterized as the one and only source, regardless of the marketplace, possessing a unique and singularly available performance capability for the purpose of contract award (Sometimes used interchangeably with the term "single source.") (DARM No. 1)

<u>Standard Integrated Support Management System (SISMS)</u>. A management approach, developed under the auspices of the joint logistics commanders (JLC), that provides a uniform way to plan and manage the logistics support of multi-service systems acquisitions. (AFR 800-8)

<u>Support Equipment</u>. Support equipment includes all equipment required to perform the support function, except that which is an integral part of the mission equipment. It does not include any of the equipment required to perform mission operations functions. (AFR 800-12)

<u>Supporting Command</u>. The command (normally AFLC) charged with responsibility for providing logistics support and designated to assume program management responsibility from the implementing command. (AFR 800-4)

Synopsis. The art of publicizing proposed Government advertised or negotiated acquisitions including modifications to existing contracts in the Commerce Business Daily.

System Acquisition Process. A sequence of specified decision events and phases of activity directed to achievement of established program objectives in the acquisition of Defense systems and extending from approval of a mission need through successful deployment of the Defense system or termination of the program. (DODD 5000.1)

System Engineering Process. A logical sequence of activities and decisions transforming an operational need into a description of system performance parameters (requirements) and a preferred system configuration. (AFSCP 800-7)

System Manager (SM). The AFLC focal point for integrating and managing the functinoal elements of logistics on a timely basis, to ensure the support of the assigned system. During the acquisition phases and before program transfer, the SM provides a vital link to the DPML or ILSM in support planning concepts. (AFR 800-8)

System Operational Concept. A formal document that describes the intended purpose, employment, deployment and support of a system. (AFR 80-14)

Time Compliance Technical Order (TCTO). Documents prepared in accordance with MIL-T-38804 (USAF) for use in accomplishing and providing a record of any one-time inspection (with or without replacement or installation of components) or in accomplishing and recording a retrofit change/alteration to the design or construction of a CI or its associated support equipment. (AFSCP 800-7)

Transfer. That point in time when the designated Supporting Command accepts program management responsibilities fromthe Implementing Command. This includes logistic support and related engineering and acquisition responsibilities. (AFR 800-4)

Transfer Working Group (TWG). A group established by the Program Manager (PM). The TWG includes representatives from the implementing, supporting, and other involved commands. The size and scope of the TWG is dependent upon the size and complexity of the program. (AFR 800-4)

Turnover. That point in time when the operating command formally accepts responsibility from the Implementing Command for the operation and maintenance of the system, equipment, or computer program acquired. (AFR 800-19)

Verification/Validation (of computer programs). The process of determining that the computer program was developed in accordance with the stated specification and satisfactorily performs, in the mission environment, the function(s) for which it was designed. (AFR 800-14, Vol. I)

Warrant. A document signed by legal authority that authorizes a person to become a contracting officer. Only warranted contracting officers can commit the Government.

Work Measurement Program. A technique for collecting data on work hours and production of work units to determine the relationship between work performed and work hours expended. Use this relationship for personnel planning, scheduling, manufacturing, budgeting, performance evaluation, and cost control. Use recognized industrial engineering techniques (time study, standards data, work sampling, or predetermined time systems) to set labor time standards. (AFSCR 84-7)

ABBREVIATIONS AND ACRONYMS

ACO	Administrative Contracting Officer
ACN	Advance Change Notice
ACWP	Actual Cost of Work Performed
AD	Armament Division
ADP	Automatic Data Processing
AEDC	Arnold Engineering Dvelopment Center
AFALC	Air Force Acquisition Logistics Center
AFCMD	Air Force Contract Management Division
AFDAP	Air Force Designated Acquisition Program
AFFTC	Air Force Flight Test Center
AFLC	Air Force Logistics Command
AFOTEC	Air Force Operational Test and Evaluation Center
AFPR	Air Force Plant Representative
AFR	Air Force Regulation
AFPRO	Air Force Plant Representatives Office
AFSC	Air Force Systems Command
AFSARC	Air Force Systems Acquisition Review Council
AGERD	AGE Requirements Document
AIS	Avionics Intermediate Shop
ALC	Air Logistics Center
AP	Acquisition Plan
ASARC	Army Systems Acquisition Review Council
ASD	Aeronautical Systems Division
ASI	Amended Shipping Instruction
ATE	Automatic Test Equipment
BA	Budget Authorization
BCWP	Budgeted Cost for Work Performed
BCWS	Budgeted Cost for Work Scheduled
BES	Budget Estimate Submission
BIT	Built in Test
BMO	Ballistic Missile Office
BOA	Basic Ordering Agreement
BSP	Business Strategy Panel
CAGEL	Consolidated AGE List
CAS	Contract Administration Services
CCB	Configuration Control Board
CCDR	Contrct Cost Data Report
CDR	Critical Design Review
CDRL	Contract Dated Requirements List
CETS	Contractor Engineering and Technical Services
CFE	Contractor Furnished Equipment
CFSR	Contractor Funds Status Report
CG	Consolidated Guidance
CI	Configuration Item
CM	Configuration Management
CMSEP	Contractor Management System Evaluation Program
CPAF	Cost-Plus-Award-Fee

CPCI	Computer Program Configuration Item
CPDP	Computer Program Development Plan
CPFF	Cost-Plus-Fixed-Fee
CPIF	Cost-Plus-Incentive-Fee
CPIN	Computer Program Identification Number
CPR	Cost Performance Report
CRISP	Computer Resources Integrated Support Plan
CRS	Computer Resources Support
CRWG	Computer Resources Working Group
CSA	Configuration Status Accounting
C/SCSC	Cost/Schedule Control System Criteria
CSP	Contract Strategy Paper
C/SSR	Cost/Schedule Status Report
DAE	Defense Acquisition Executive
DAR	Defense Acquisition Regulation
DCAA	Defense Contract Audit Agency
DCAS	Defense Contract Administration Services
DCASMA	Defense Contract Administration Services Management Area
DCASR	Defense Contract Administration Services Region
DCASPRO	Defense Contract Administration Services Representatives Office
DCP	Decision Coordinating Paper
DD 250	Air Force Accepting/Title Transfer
D&F	Determination and Finding
DLA	Defense Logistics Agency
DPML	Deputy Program Manager for Logistics
DPS	Decision Package Sets
DR	Deficiency Report
DRED	Deferred Requisitioning of Engineering Drawings
DSAA	Defense Security Assistance Agency
DSARC	Defense Systems Acquisition Review Council
DT&E	Development Test and Evaluation
ESMC	Eastern Space and Missile Center
ECP	Engineering Change Proposal
EM	Energy Management
ESD	Electronic Systems Division
FA	Facilities
FCA	Functional Configuration Audit
FCI	Functional Configuration Identification
FFP	Firm-Fixed-Price
FMR	Functional Management Review
FOT&E	Follow-On Test and Evaluation
FPIF	Fixed-Price-Incentive-Firm
FPLOE	Fixed-Price Level of Effort
FQT	Formal Qualification Testing
FSN	Federal Stock Number
FYDP	Five Year Defense Program

GAO	General Accounting Office
GBL	Government Bill of Lading
GFE	Government Furnished Equipment
GFP	Government Furnished Property
ICWG	Interface Control Working Group
IFB	Invitation for Bid
ILC	International Logistics Center
ILS	Integrated Logistics Support
ILSM	Integrated Logistics Support Manager
ILSP	Integrated Logistics Support Plan
ILS T&E	Integrated Logistics Support Test and Evaluation
IM	Item Manager
IOC	Initial Operating Capability
IOT&E	Initial Operating Test and Evaluation
ISP	Integrated Support Plan
JMENS	Joint Mission Element Need Statement
JOP	Joint Operating Procedure
JOR	Joint Operational Requirement
JPAM	Joint Program Assessment Memorandum
JPO	Joint Program Office
JSPD	Joint Strategic Planning Document
JTD	Joint Test Director
JT&E	Joint Test and Evaluation
JTF	Joint Task Force
LCC	Life Cycle Cost
LOA	Letter of Offer/Acceptance
LRU	Line Replaceable Unit
LSA	Logistic Support Analysis
LSMI	Logistics Support Management Information
LSRF	Logistics Support Resource Funds
MAA	Mission Area Analysis
MACSO	Military Airlift Command Support Office
MDR	Materiel Deficiency Report
MENS	Mission Element Need Statement
MIPR	Military Interdepartmental Purchase Request
MOA	Memorandum of Agreement
MPT	Manpower, Personnel and Training
MP	Maintenance Planning
MSI	Management System Indicator
MRP	Manpower Requirements and Personnel
MST&E	Multiservice Test and Evaluation
MTS	Mobile Training Set
NAVPRO	Naval Plan Representative Office
NRTS	Not Repairable This Station

NSARC	Navy Systems Acquisition Review Council
NSN	National Stock Number
OMB	Office of Management and Budget
ORLA	Optimum Repair Level Analysis
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
PA	Program Authorization
P&A	Price and Availability
PAGEL	Priced AGE List
PAR	Program Assessment Review
P&B	Planning and Budgeting
PD	Program Director
P&R	Planning and Resources
PCA	Physical Configuration Audit
PCI	Product Configuration Identification
PCO	Principal Contracting Officer
PDM	Program Decision Memorandum
PDR	Preliminary Design Review
PE	Program Element
PHT	Packaging, Handling and Transportation
PI	Program Introduction
PM	Program Manager
PMD	Program Management Directive
PMEL	Precision Measurement Equipment Lab
PMP	Program Management Plan
PMRT	Program Management Responsibility Transfer
PMRTP	Program Management Responsibility Transfer Plan
P/N	Part/Number
PO	Program Office
POM	Program Objective Memorandum
PPBS	Planning, Programming and Budgeting System
PQT	Preliminary Qualification Testing
PR	Purchase Request
PRG	Program Review Group
PRR	Production Readiness Review
PT	Personnel and Training
QA	Quality Assurance
QAM	Quality Assurance Manager
QOT&E	Qualification Operational Test and Evaluation
QT&E	Qualification Test and Evaluation
RDT&E	Research, Development, Test and Evaluation
RFP	Request for Proposal
RFQ	Request for Quotation
RIB	Recoverable Item Breakdown
R&M	Reliability and Maintainability

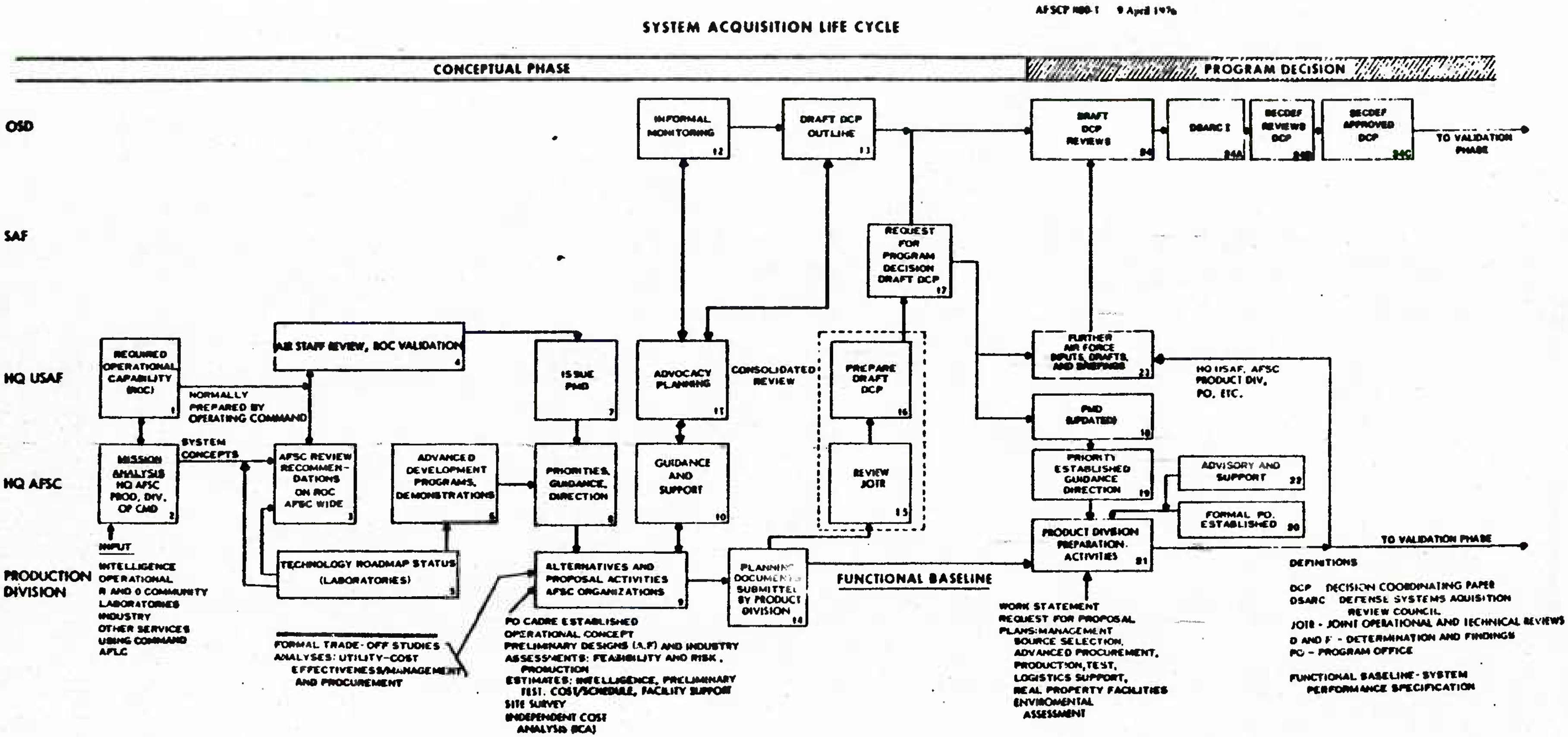
SA	Supplemental Agreement
SACSO	Strategic Air Command Support Office
SAF	Secretary of the Air Force
SAR	Selected Acquisition Report
SATAF	Site Activation Task Force
SCT	System Compatibility Test
SD	Space Division
SDDM	Secretary of Defense Decision Memoradum
SDR	System Design Review
SE	Support Equipment
SECDEF	Secretary of Defense
SERD	Support Equipment Requirements Document
SISMS	Standard Integrated Support Management System
SM	System Manager
SMR	Source Maintenance Recoverability Code
SOC	Statement of Capability
SON	Statement of Need
SOW	Statement of Work
SPDR	System Program Director's Review
SPR	Secretary of the Air Force Program Review
SRP	Solicitation Review Panel
SRR	System Requirements Review
SRU	Shop Replaceable Unit
SS	Supply Support
SSA	Source Selection Authority
SSAC	Source Selection Advisory Council
SSEB	Source Selection Evaluation Board
SV	Survivability
TACSO	Tactical Air Command Support Office
TCO	Termination Contracting Office
TCTO	Time Compliance Technical Order
TD	Technical Data
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TH	Transportation and Handling
TO	Technical Order
TPWG	Test Planning Working Group
TWG	Transfer Working Group
UUT	Unit Under Test
V&V	Verification and Validation
WBS	Work Breakdown Schedule
WRSK	War Readiness Spares Kit
WSEP	Weapon System Evaluation Program
WSMC	Western Space and Missile Center
WUC	Work Unit Code

APPENDIX C

SUMMARY OF MAJOR ACQUISITION ACTIVITIES

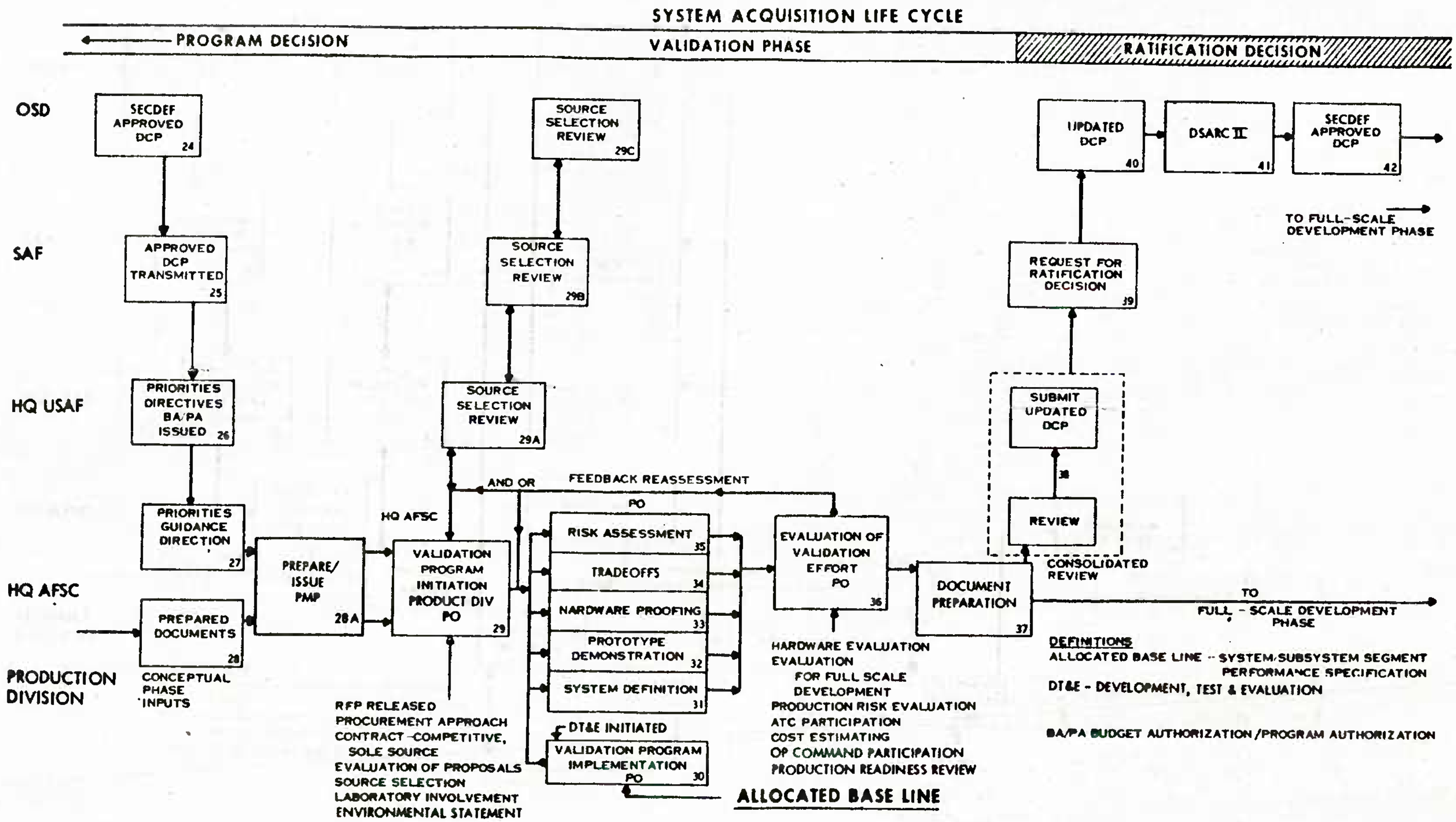
APPENDIX C. SUMMARY OF MAJOR ACQUISITION ACTIVITIES

This appendix contains additional detail on the major acquisition activities the PM must manage. There are three parts to this appendix. The first part (pages C-1 to C-4) includes a set of four exhibits showing the flow of activitiy in the Concept Exploration, Demonstration and Validation, Full-Scale Development and Production phases. The second part (pages C-5 to C-23) is an annotated listing detailing the activities/events, the groups involved and descriptive comments regarding the activity or event. These first two parts are taken from AFSCP-800-3, A Guide for Program Management, currently in revision and no longer in print. The third part of this appendix (pages C-24 to C-30) is a set of exhibits illustrating the typical organization of the various directorates in a typical program office. These have been taken from the Weapon System Acquisition Guide.



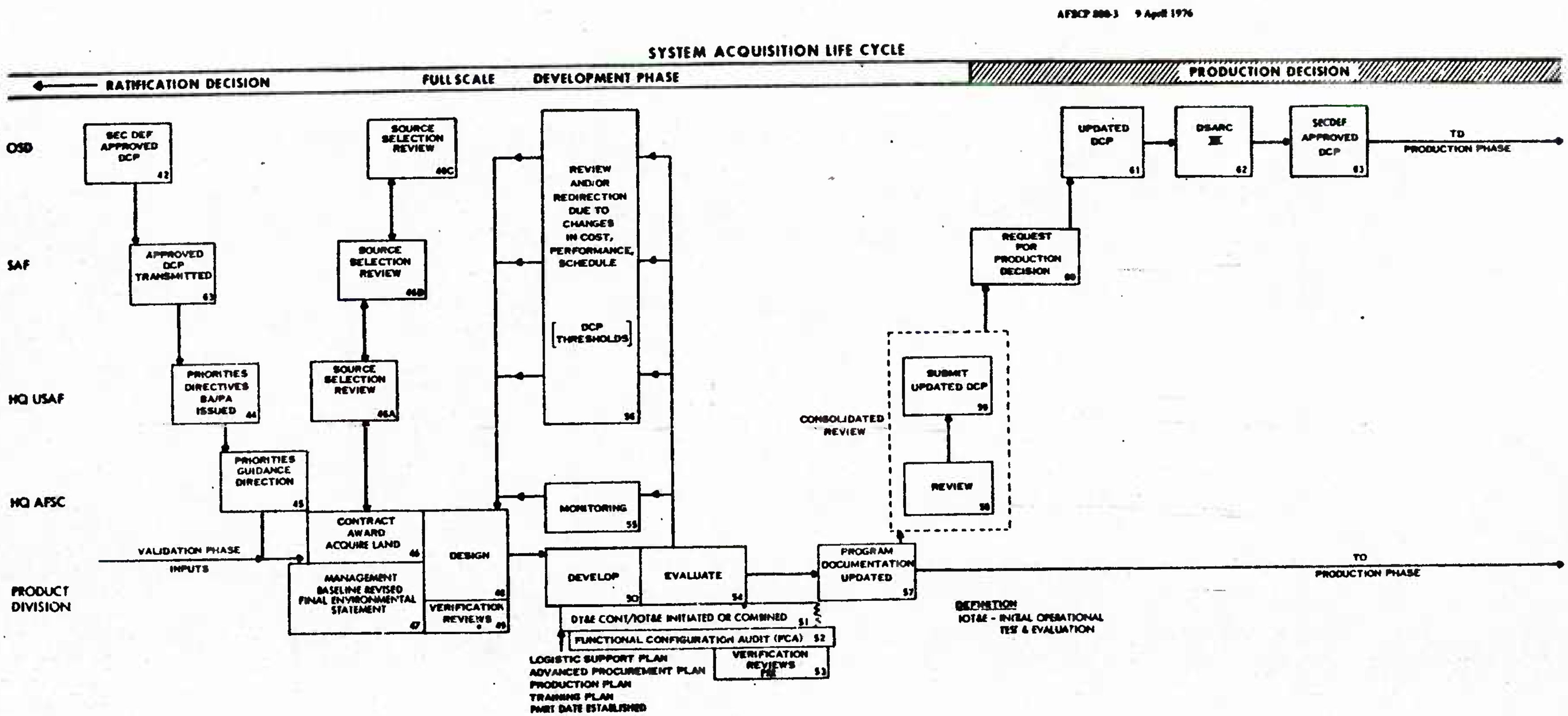
Source: A Guide for Program Management, AFSCP 800-3, Air Force Systems Command, 9 April 1976

Exhibit C-1. ACTIVITY FLOW IN CONCEPT EXPLORATION PHASE



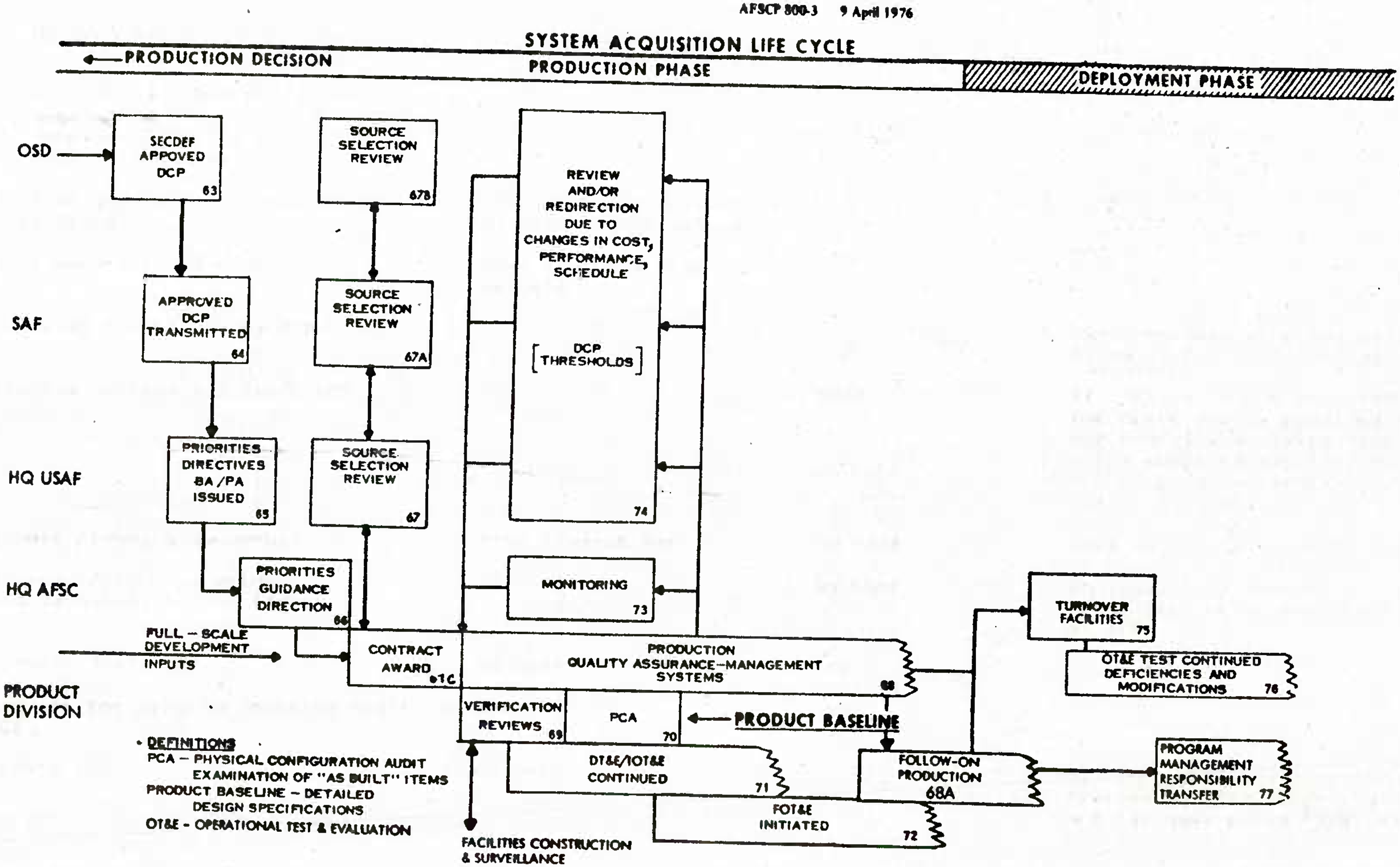
Source: A Guide for Program Management, AFSCP 800-3, Air Force Systems Command, 9 April 1976

Exhibit C-2. ACTIVITY FLOW IN DEMONSTRATION AND VALIDATION PHASE



Source: A Guide for Program Management, AFSCP 800-3, Air Force Systems Command, 9 April 1976

Exhibit C-3. ACTIVITY FLOW IN FULL-SCALE DEVELOPMENT PHASE



Source: A Guide for Program Management, AFSCP 800-3, Air Force Systems Command, 9 April 1976

Exhibit C-4. ACTIVITY FLOW IN PRODUCTION PHASE

Summarized from AFSCP-800-3

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	Concept Exploration Phase			
1	• Prepare ROC and maintenance concept	Oper. Commands/MAJCOMs	Submitted to AFSC	initiates CE phase
2	• Perform mission analysis	Oper. Commands/MAJCOMs		initiates ROC; used during review and valid. of ROC
3	• AFSC ROC Review and Recommendation	AFSC	HQ USAF	AFSC submits ROC to HQ USAF for use to validate ROC and prepare directive for action
4	• Air Staff Review, ROC Validation	Air Staff		
5	• Prepare Technology Roadmap (TR)			TR info. applied to ROC before HQ USAF review; info affects ROC input; identifies status of adv. develop. programs and demo.
6	• Advanced Development Programs			implement tasks identified in TR
7	• Issue Program Mgt. Directive (PMD)	HQ USAF	HQ USAF and OSD	translates ROC into proposal for new program
8	• Establish program priorities and direction	HQ USAF receives PMD and sends it to HQ AFSC		HQ AFSC est. program priority and issues direction to AFSC organizations via AFSC Form 56
9	• Consider alternatives and proposal activities - includes the following:	AFSC and Oper. Commands	HQ USAF	info. is used to prepare program develop./acquisition plan, advocacy documents by Air Staff, and parts of the DCP
	- est. program office (PO) - initiate operational concept	Oper. Commands	AFSC	- should be done early in CE phase; info. serves as basic input for PD
	- prepare preliminary design (PD)	AFSC and contractors		- compare competing alt. system design; info. serves as input to other activ. of period
	- evaluate feasibility and risk assessment			- provides specific D&T activity for demonstration hardware in Validation Phase
	- est. production feasibility assessment			- identifies prod. develop., tests and demo. to be accomplished in FSD Phases
	- est. logistics support estimate - est. intelligence estimate - est. preliminary test estimates -- est. cost/schedule estimate - perform formal tradeoff studies - perform utility cost/effectiveness analysis, LCC/DTC strategy			See AFSCP 800-3, pp. 2-6 to 2-7

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	<u>Concept Exploration Phase</u>			
	- analyze mgt. and procurement approaches - consider facility support estimate/site survey			
10	• Provide guidance and support to activities	AFSC monitors activities of AFSC organizations		
11	• USAF advocacy and planning	USAF monitors AFSC efforts		
12	• Informal monitoring by OSD			OSD considers proposed system in terms of DoD-wide context
13	• Prepare outline for draft DCP	OSD	USAF	if outline is not prepared guidance for draft DCP is provided to AF; DCP contains decision-review thresholds which if exceeded cause SECDEF program review; see AFSCP 800-3, p. 2-8.
14	• Submit planning documents	AFSC Program Mgr.	HQ USAF	used as inputs to draft DCP
15	• Arrange Joint Operational and Technical Review (JOTR)	HQ AFSC	HQ USAF	arranged <u>only</u> when directed by the Commander, AFSC, see AFSCP 800-3, p. 2-8.
16	• Prepare draft DCP	HQ USAF	SAF	
17	• Request for program decision draft DCP	SAF	OSD	
18	• Update PMD	HQ USAF		HQ USAF publishes directives in a revised PMD for preparing a draft RFP for next phase (usu. Validation)
19	• Est. program priority and issue guidance and direction	HQ AFSC receives revised PMD from HQ USAF		See AFSCP 800-3, p. 2-8
20	• Est. formal PO			See AFSCP 800-3, p. 2-8
	- PM should select and have his staff by product division preparation activities - functional baseline (program req'ts baseline) is est. by end of CE phase			
21	• Consider product division preparation activities			See AFSCP 800-3, p. 2-9

Summarized from AFSCPP-800-3

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	- PMP updated and submitted as master plan			
	- master plan implements activities in Block 9			
	- contents of PMP such as SON, RFP mgt. plan, source selection, adv. procurement, product., test, logistics support, etc.			See AFSCP 800-3, p. 2-9
	- PM prepares Systems Command Information Plan (SCIP)			- should be prepared 60 days before RFP release
	- prepare D&F			- must be prepared prior to releasing RFP; normally approved by Service Secretary
	- prepare advanced procurement plan	PM		- plan is revised procurement approach of that est. in Block 9
	- review of RFP by AFSC Proc. Eval. Panel			- done only when AFSC Form 56 transmitting the PMD so specifies
	- prepare initial TEMP			- should be done in CE Phase
	- production planning			- should emphasize resolution of production risks identified in Block 9
22	● Consider HQ AFSC guidance and support			support provided in preparing SOW and RFP
	- Procur. Eval. Panel (PEP) may meet at HQ AFSC to eval. RFP's			
23,24	● Reviews of draft DCP	OSD reviews and comments on DCP		
23,24	● Revision of DCP to reflect OSD comments	USAF	OSD	
23,24	● Revised DCP becomes "for coordination" draft used as basis for DSARC action			
24A	● Initiate informal pre-DSARC staff meeting			not required, but should precede DSARC review by 60 days
24A	● Consider other activities preceding DSARC mtg:			
	- DDR&E (T&E) Test and Eval. Report			
	- Chairman of CAIG eval.			
24A	● DSARC review meeting			
24A	● Prepare stmt of objectives and memorandum	DSARC Chairman	SECDEF	provided within 15 days after DSARC review

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	Concept Exploration Phase			
24B	• SECDEF review of DCP			
24C	• SECDEF aproval of DCP			constitutes program initiation decision approved DCP signed by SECDEF published within 30 work-days after SECDEF decision is made; begin Demo. & Val. Phase forwarded to HQ USAF with funding req'ts consistent with FYDP
	Demonstration & Validation Phase			
25	• Approved DCP transmitted by SAF			
26	• Issue priorities, directives, Budget Auth./Procure. Auth. (BA/PA)	HQ USAF		AFSC BA issued for ea. FY increment (or entire FY program see - AFSCP 800-3, p. 3-1.
26A	• Develop initial drafts of prog. supplements to PMD	PM & PO		
27	• Issue AFSC priorities, guidance and direction	HQ AFSC	PO	
28	• Prepare/issue PMP documents which include the following: - revise and supple. req'ts bsline doc. prepared in Block 22			See AFSCP 800-3, p. 3-5
28A	• Prepare/issue PMP	PM		PM is responsible for overall preparation and issuance of PMP with coordination from AFLC, ATC, AFOTEC and the operating command; principal program mgt. baseline document; should be kept up-to-date; tailored to needs of the program
29	• Initiate validation program: - est. realistic perform. specif. (alloc. bsline) which meet the O&S req'ts. - est. schedule and cost estim for FSD phase - est. planning schedules and cost estim for product. - achieve RFP release - develop procurement approach	PO	contractors	develop this early in acquisition process consider contract types -

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	<u>Demonstration & Validation Phase</u>			
29	• Consider Validation by competitive contactors DoD-financed; under PM's guidance			
29	• Consider Validation by sole-source contractors			Valid. Phase may be on sole-source basis if competition is not feasible-decision is made by SAF based on PM recommendation
29	• Consider evaluation of proposals by SSAC			
29 A/B/C	• Initiate source selection and contract award			procedures described in AFM 70-6 and AFR 70-15 may be used for any Valid. Phase approach in Air Force
30	• Implement validation program			
30	• Transition from functional to allocated bsline			See AESCP 800-3, p. 3-7
30	• Initiate DT&E and prepare T&E Master Plan AFSC test center and PM			DT&E of subsystems begins in valid. Phase-feasibility testing should begin earlier; check to insure that design is functional
	• Develop procurement plan - consider the following: - incentive provisions - procurement/production leadtimes - valid. of cost and price estimates - logistics req'ts - equip. and spares req'ts - facility req'ts - pers. and training req'ts			
	• Est. allocated bsline (design req'ts bsline)			should satisfy objectives of functional bsline (program req'ts bsline) see AFSCP 800-3, p. 3-7
31	• Produce system definition			Valid. Phase should produce a more detailed system definition as functional bsline grows into allocated bsline
	• Begin contractor FSD PMP	specified by PO		See AFSCP 800-3, p. 3-8
	• Consider design standardization			

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	<u>Demonstration & Validation Phase</u>			
32	• Initiate prototype demonstration	operating command participates		degree of prototyping and number of system segments, subsystems to be prototyped should be defined in Valid. Phase adv. procure. plan. See AFSCP 800-3, p.3-9
33	• Initiate hardware proofing	decision made by PM		
34	• Perform tradeoff studies			studies ensure that configuration being defined for FSD is balanced among total cost, schedule and operational effectiveness; changes to any of above require DCP/DSARC procedure; see AFSCP 800-3, p. 3-9
35	• Perform risk assessment (should be done continually)			should identify and order elements of risk which constitute the most important uncertainties in FSD phase
36	• Evaluation validation effort which includes operating commands participate the following: - design to cost goals (when required by PMD) must be produced during this phase and expressed as cost ceilings - identify performance and schedule trade-offs - hardware evaluation - cost estimating - production risk evaluation - ATC participation - evaluation for FSD which includes a PRR			- if required, should be planned for in Block 3 - results of this review are reflected in RFP for FSD and in approval documentation for Ratification Decision
37	• Initiate document preparation which includes: - update DCP, PMP, Adv. Procure. Plan - contracts for FSD and production phases should generally be separate			

Summarized from AFSCP-800-3

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	<u>Demonstration & Validation Phase</u>			
38	• Submit updated DCP	HQ USAF	SAF	PM cannot influence time it takes to get Ratification Decision DCP approved; DCP <u>must</u> be kept current
39	• Request for Ratification Decision	SAF reviews program doc.	DSARC	
40	• Update DCP			DCP is updated to satisfy req'ts of FSD
41	• DSARC II			DSARC reviews updated DCP and other prog. doc.
42	• SECDEF approval of DCP			approval of DCP constitutes the Ratification decision; decision depends on confirmation of tech-technical, financial and schedule constraints because of the Validation Validation Phase, the Air Force will make one of the following recommendations to: (1) Contract for full-scale development. (2) Continue further Validation Phase effort. (3) Defer or abandon the development effort. (4) Undertake further exploratory or advanced development of key components and/or system studies. Approval into FSD is based on: (1) System tradeoffs have produced a balanced and realistic set 6 performance parameters. (2) Risk areas have been identified and reduced to acceptable levels. (3) Cost/schedule estimates for full-scale development are acceptable. (4) Contractual aspects are sound (terms and conditions are appropriate to risk and funding related to milestones).
	• Identify required changes to funding, schedules, and technical planning that will effect Production Phase			

Summarized from AFSCP-800-3

BK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	Full Scale Development Phase			
43	• Transmit approved DCP	SAF forwards DCP to HQ USAF		
44	• Issue HQ USAF directives, BA/PA	HQ USAF forwards DCP to AFSC		HQ USAF releases funds for Development Plan through BA/PA actions
45	• Issue AFSC guidance and direction			
46	• Award contract according to approved DCP			See AFSCP 800-3, p. 4-1
46 A/B/C	• Initiate Source Selection Review			source selection documents are submitted to the designated level for review and decision making
47	• Revise management baseline			changes in mgt. plans and documentation are completed to make program plans compatible with approved FSD phase and FSD DCP
48	• Initiate design activity	contractor		this represents the iterative design effort accomplished by the contractor during FSD; major effort of preliminary detail design leading to developing an acceptable design approach should begin at this point; reduce production risks and prepare for Final PRR
49	• Conduct Verification Reviews			PDR for ea. CI is conducted before beginning detailed design process; AF position on design is est. as result of Verification Reviews; PM can request the use of Independent Technical Audit/Assessment performed at his discretion
50	• Develop/demonstrate production techniques			consider using the "Fly-Before Buy" approach
	• Update documentation for development			the following doc. require updating during the early stages of FSD: a. Logistic Support Plan b. Training Plan c. Advanced Procurement Plan d. Production Plan e. Subcontract Mgt. Plan

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
				f. PMRT Agreement g. Turnover Agreement h. to Mgt. Plan
51	● Continue DT&E which includes:			
	- contractor DT&E	contractor		- during FSD contractor should expand/revise TEM test normally consists of testing CI's and usu. completed before PCA; plan and procedures should follow QA and system specif. req'ts
	- AF DT&E	AF		- during FSD AF should expand/revise TEMP; procedures should implement QA and system specific req'ts; also emphasize integrated eval. of system segments required for mission
	- Est. PMRT date	implementing command PM and supporting command SM	forwarded to HQ USAF	- during FSD the respective PM & SM jointly est. PMRT date (PMRTD); formal PMRTD is forwarded to HQ USAF for inclusion in the production PMD; PMRT will occur at the earliest possible date in the production phase:
	- Logistics Support Plan - Advanced Procurement Plan - Production Plan - Training Plan			
52	● Begin FCA			FCA begins when DT&E completed; FCA is complete when CI is qualified
53	● Begin Verification Reviews			qualif. of USAF equip (GFAE, subsystems) may be given at this time or withheld until after the verification reviews and tests of Product. Phase
	- CDR should occur before start of DT&E/IOT&E - PRR should be coonduct at this point in the Development Phase - other design and program reviews should be held at significant milestones to confirm accomplish. and eval. tech. progress before production phase	performed by product. element in PO		

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
54	• Evaluate development testing			this activity shows evaluation of testing completed in FSD phase; make any necessary engineering changes
55	• Monitor program	HQ AFSC		HQ AFSC monitors the program during FSD
56	• Review/redirect program (DCP thresholds)			technical direction from higher levels is not expected during FSD unless thresholds are broken or threatened
57	• Update program documentation			product identification baseline should be as complete as possible for the production contract RFP, even though updating will continue until the PCA; the majority of DT&E, including some IOT&E, if schedule permits, should be completed before the product baseline is established to avoid the cost of processing formal engineering changes required from DT; product bsline is placed at end of qualification testing; before award of production contract a plan for turnover to oper. command and PMRT identifi. doc. to AFLC should be formalized-should be done early enough to provide for programming and funding req'ts; prepare independent cost estimates.
58/59	• Review/submit updated DCP	HQ USAF	SAF	
60	• Request production decision			Approval to proceed into the production phase will be based upon assurance that: a. risks (including threat) have been resolved b. costs, schedule and performance estimates/req'ts for production phase are credible c. certification by credible DoD component that: 1) practical engineering design has been completed 2) tradeoffs have optimized product, mtn. and oper. costs

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
				3) contractual aspects are sound
61	• Update DCP			DCP is updated in preparation for the production phase
62	• DSARC III decision			program doc. should be checked against DSARC checklist (see APSCP 800-3, Attachment 1) to determine if all aspects of FSD phase have been completed.
63	• SECDEF approval of DCP	SECDEF decision after consultation with DSARC		SECDEF approval of DCP initiates Production Phase
	• There are two distinct periods of production: 1.) first segment immediately follows FSD, where: - hardware manufact. is at peak rate - hardware changes from FSD and early prod testing are implemented 2.) second segment implements follow-on production after peak rate is achieved.			
	<u>Production and Deployment Phase</u>			
64	• Transmit SAF-approved DCP		Transmitted to HQ USAF USAF	
65	• Issue USAF priorities, directives and BA/PA	HQ USAF		HQ USAF deter./reaffirms program priories, issues direction and releases program funds for Production Phase through BA/PA actions
	- obtain program element numbers for OSD production fund scheduling	HQ USAF	OSD	- done after program decision
66	• Issue AFSC priorities, guidance and direction	HQ USAF		
67 67A/B	• Imitate Source-Selection review			source-selection doc. or sole-source recommendation preceeded by contract negotiations, are submitted for review and decision
67C	• Consider contract award			doc. prepared during FSD for Production Phase are revised to reflect DCP guidance
68	• Consider production mgt and QA mgt			

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
68A	• Consider follow-on production			this initiates second segment of production, review previous production decisions
69	• Initiate verification reviews			reviews should continue on a periodic basis to assure that design continues to be feasible and sound; CDR is completed before DCA
70	• Continue Physial Configuration Audit (PCA)			PCA is a formal audit that compares Part II Detail (Product Fabrication) Specif. and accompaning drawings against product, hardware; also deter. that acceptance test req'ts are adequate; product of PCA is PM acceptance of above specific; PCA is prerequisite to configuration item acceptance; successful completion of PCA est. approved product configuration bsline for CI and begins formal engineering change control for class I design changes
71	• Continue DT&E/IOT&E			continue testing from FSD phase
72	• Initiate FOT&E	AFOTEC		should be conducted on early product, mode or after the command has accepted the first operating unit and its updated changes
74	• Consider reviews and redirection due to changes in cost, performance, schedule	PM		technical direction from higher levels is not expected during production
75	• Begin formal turnover of facilities			turnover occurs when oper. command accepts responsibility for operation and mtn of new system; details of turnover are set forth in Formal Turnover Agreement
76	• Continue OT&E for deficiencies and modifications	AFTEC or Oper. Commands evaluates OT&E results; PM should have authority within the program to decide on updates; if modifications are required HQ USAF should designate implementing command		complete logistical support is required to test the system in an operational environ.
77	• Begin Produce Management Responsibility Transfer (PMRT):	termination of AFSC PM responsibility; AFLC assumes logistics and mgt. responsibility		PMRT planning begins early in FSD see AFSCP 800-3 pp. 5-6 to

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	- PMRT should be scheduled and reported as a major milestone - PMRT date should be negotiated by the PM w/AFLC/ALC SM - PMRT date should be early in the product. phase and after completion of DT when design has stabilized - PO should be dissolved after PMRT and replaced w/Project Office			5-7
	• Begin deployment planning			consider support required for newly fielded system (i.e., mtn, training); est. feedback procedures for field generated data needs of PO deter., type of schedule used
	<u>Program Control Considerations</u>			
	• Consider various types of schedules: - process charts - Gantt charts - milestone charts - line of balance (LOB) technique - networking			see AFSCP 800-3 pp. 6-9 tp 6-10
	• Consider planning which should be done: - when interdependent activities are involved - to ensure quality decisions			
	• Est. relationship w/external activities such as DCAS, AFPROs, etc.			should be done early in program's life and confirmed in writing by Memorandum of understanding
	• Determine program direction	HQ USAF		
	• Determine organization of program control element in the program office			see pp 6-1 to 6-2
	• Review of AFSC acquisition program at various milestones or when warranted which includes: - Commanders Daily Staff Mtg - Mission Mgt. Review - Executive Mgt. Review - Staff Presentations		Command reviews program status	see Fig. 6-3 (from AFSCP 800-3) for more detail - performed daily - monthly status report of Develop. Planning, etc. ea. reviewed quarterly - monthly status report - done as required

Summarized from AFSCP-800-3

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	- Program Assessment Review (PAR)			- quarterly status of ea. major system program
	- SAF Program Review (SPR)			- updated monthly between quarters
	- Command Assessment Review (CAR)			- each program reivewed quarterly; CARs are held weekly
	- Field Assessment Review (FAR)			- held semi-annually
	- Mgt. Assessment Review (MAR)			- review by product division Commander of program involving more than $2M to complete; not review by AFSC unless nominated for CAR
	● Consider roles of - SYSTO - DCASO/AFPRO - PEM			SYSTO is POC at HQ AFSC DCASO/AFPRO administers contracts PEM is POC w/HQ USAF
	Engineering Management Considerations			
	● Consider engineering mgt should be used in all acquisition phases			process for managing the engineering effort should be uniform
	● System engineering mgt should be used in all acquisition phases			see pp. 8-3 to 8-4 for details
	● Consider Technical Reviews			number and type of reviews depend on complexity of the aquisition
	● Consider system Req'ts Review (SRR)			see AFSCP 800-3 p. 8-5
	● Consider System Design Review (SDR)			should be conducted as final review before submittal of valid phase products or as intial FSD review for systems not requiring formal valid phase; if SDR is satisfactory functional beline should be updated and contracttor enters into prelim. design; see AFSCP 800-3 p. 8-5
	● Consider Preliminary Design Review (PDR)			should be conducted for ea. CI in system; successful PDR is required for ea. CI before proceeding into detail design, see AFSCP 800-3 p. 8-5
	● Consider Critical Design Review (CDR)			review should be conducted before design is committed to production; see AFSCP 800-3 p. 8-5
	● Consider Functional Configuration Audit (FCA)			see AFSCP 800-3 p. 8-5

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	• Consider Physical Configuraiton Audit (PCA)			see AFSCP 800-3 p. 8-6
	• Consider Formal Qualification Review (FQR)			at the FQR, the CI is certified for entry into the gov't inventory; see AFSCP 800-3 p. 8-6
	• Consider Technical Interchange/ Direction Meetings (TI/D)	done at direction of PM		
	• Consider Independent Reviews			
	• Consider decision risk analysis			see AFSCP 800-3 p. 8-7
	• Initiate Technical Performance Measurement (TPM)			initiated during Valid Phase after design-to req'ts of the product elements are defined and continues throughout FSD into Production and Deployment Phases
	• Consider reliability during acquisition which includes the following:			
	- perform ROC analysis			- done during Conceptual Phase
	- update and refine system anlaysis			- done during Valid Phase to Conceptual Phase Info
	- numerical reliability req'ts - reqt's allocation - part selection and standardization - design analysis and prediction - design reviews - demonstration (qualif.) testing			done during FSD when reliability activity is at its highest level; see AFSCP 800-3 pp. 8-9 to 8-10
	- quality assurance - R&M production (verification) testing - R&M update changes			done during Production Phase; see AFSCP 800-3 p. 8-10
	• Consider maintainability program			should be coordinated with AFLC throughout the development program; mtn. concept and design should stabilize by FSD; a maintainability demonstration is necessary at the end of FSD
	• Consider procedures in mtn. analysis: - level of repair analysis (LORA) - maintainability apportionment - failure mode analysis			
	• Develop detailed maintenance plan			this will be incorporated in the ILS plan developed by AFLC

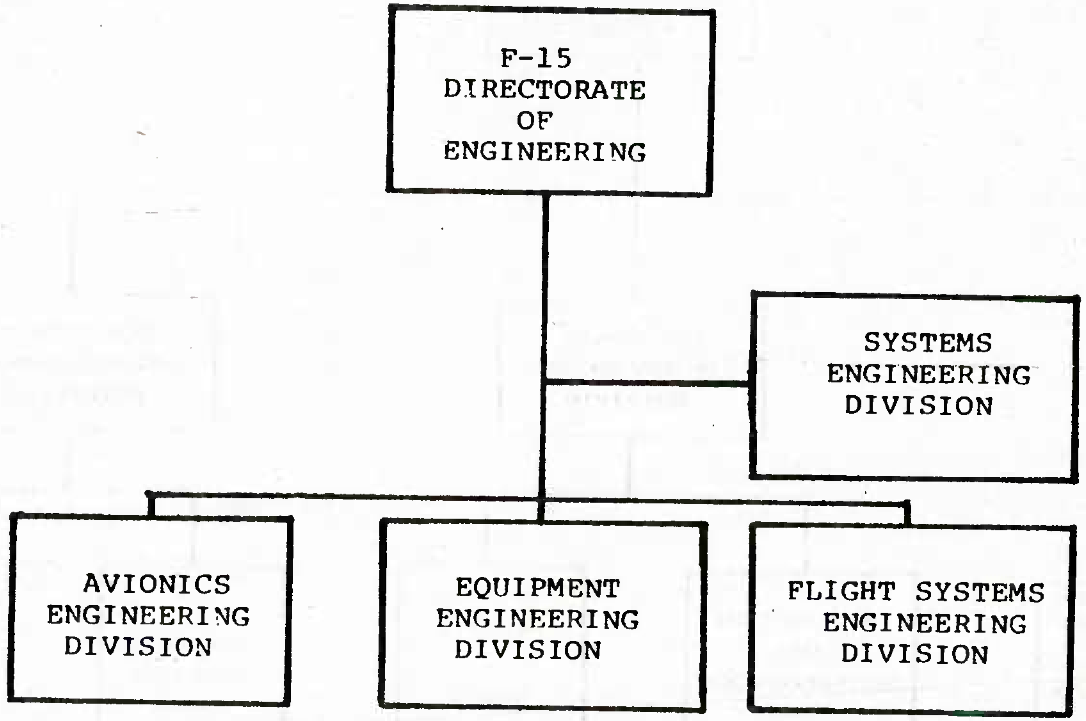
Summarized from AFSCP-800-3

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	<u>Configuration Management Considerations</u>			
	• Consider configuration mgt.			applied during life cycle of systems and all CI
	• Consider Baseline Mgt. Three baselines are normally est. These are:			a fundamental concept of engineering mgt is the use of a series of technical baselines to ensure an orderly transition from one major decision point to the next throughout the Acquisition Life
	a. Functional Baseline			a. normally est. at end of Conceptual Phase and is Concurrent w/initiation of Valid. Phase
	b. Allocated Baseline			b. normally est. at end of Valid. Phase
	c. Product Baseline			c. normally est. before or at PCA during the latter part of FSD; see also AFSCP 800-3 p. 9-2 and Fig 9-1
	• Consider Class I vs. Class II changes			Class I changes effect contractually specified items and must be approved by the CCB chairman; Class II engineering changes must be reviewed by plant representative for concurrences in classification
	<u>Test and Evaluation Considerations</u>			
	• Consider role of PO in T&E			see Fig. 10-2 from AFSCP 800-3
	• Consider Critical Questions and Areas of Risk in testing			consider these areas as discussed in the PMO'
	• Update test plans			when TEMP is updated due to design changes, detailed test plans must also be updated
	<u>Other Program Management Considerations</u>			
	• Consider PRR's			should be accomplished and documented before production decision; preparation for PRR should be initiated at inception of design; long leadtime items may require incremental PRR's

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	• Consider production feasibility assessment			should be accomplished in the Conceptual Phase of develop. cycle before program decision
	• Consider ILS planning which includes: - develop ILS plan	PO, ATC, AFLC, Oper. Comm.		milestones are est. to coincide with other important system milestones
	- conduct LSA (mil. std. 1388)			may be required as part of the RFP
	• Consider training and training equipment planning			should be considered during all acquisition phases
	• Consider interface mgt. during all acquisition phases			see AFSCP 800-3 pp. 15-1 to 15-3
	• Consider data during acquisition cycle			CDRL is introduced (see AFSCP 800-3 p. 16-1)
	• Consider possibility of Security Assistance Programs (SAP)			see AFSCP 800-3 chap. 19
	• Consider Program office organ. listed below is various info relating to a PO			see AFSCP 800-3 chap. 20
	- est. program Cadre			done early in Conceptual Phase phase in appropriation AFSC AFSC Product Division according to direction rec'd from HQ AFSC and HQ USAF; cadre prepares DCP, PMP etc.; see Fig. 20-2
	- relationship between organ. elements for program mgt and DSARC			see Fig. 20-1 from AFSCP 800-3
	- est. formal program office			achieved after Conceptual Phase when a new or revised PMD direction entry into Valid. Phase (or later phase) is issued
	- consider various types of PO organization			see Figs. 20-3 to 20-7 (from AFSCP 800-3); PO is organized as a mission element in one of the AFSC product Divisions
	- consider responsibilities of: Program Control, Configuration Mgt, Procurement Function, Production Mgt			see AFSCP 800-3 pp. 20-11 to 20-14

BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
	Engineering Function T&E ILS Mgt Support MAJCOM Liason Offices			
	• Synchronize manpower req'ts			manpower req'ts should be synchronized with program milestone objectives; PMP should contain organiz. and manpower data for both acquisition and operational phases. This info. is important in Valid. Phase to secure additional manpower authorizations
	• Consider use of METs			aid Project Director in estimating the manpower needs of his program during acquisition
	• Phaseout of PO which includes: - transfer of mgt. responsib. from AFSC to AFLC - providing for operational life engineering support req'ts			AFSC is responsible for all system engineering during conceptual, Valid. and Product Phases; AFLC is responsible for operational engineering of the system during deployment phase; AFLC will assume operational engineering responsibility for those items officially accepted by the oper. command and have become part of operational inventory; AFSC retains overall responsbility for system engineering decisions
	• Consider deployment aspects			address deployment aspects to the maximum extent practicable during the Conceptual and Valid. Phases; planning should be est. by PM with representatives of participating organiz. early in FSD
	• Incorporate deployment oriented tasks and schedules into PMP			deployment oriented tasks and schedules should be est. as program mgt. milestones
	• Consider PMRT date			for those programs directed by PMD, date for PMRT is determined by AFSC and AFLC during FSD phase and forwarded to HQ USAF for inclusion in production PMD-once est. PMRT data cannot be changed

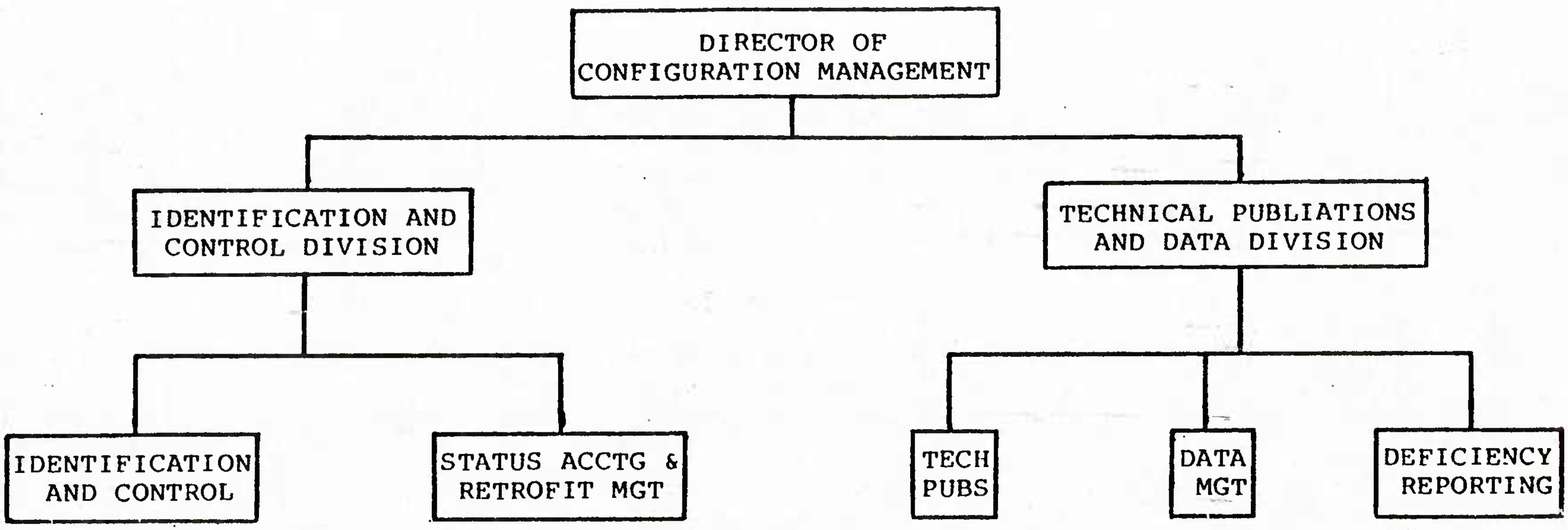
BLOCK #	ACTIVITY/EVENT	PREPARED BY	PREPARED FOR	COMMENTS
				except by HQ USAF based on a joint recommendation for the change by Commanders, AFSC and AFLC; for those programs not directed by PMD, PMRT is est. by a joint command document - est. date may not be changed except by agreement between Commanders, AFSC and AFLC. As PMRT date approaches a jointly coordinated agreement is prepared listing residual tasks to be performed by AFSC and schedule for their completion - this schedule is forwarded to HQ USAF 30 days before est. PMRT date for review, approval, and issuance by PMO
	• Consider turnover problems			see AFSCP 800-3 pp. 21-7 tp 21-8
	• Attachment 4 of AFSCP provides info. on "How to Prepare a PMP"			



Source: <u>Weapon System Acquisition Guide</u>, (Air Command and Staff College, May 1981)

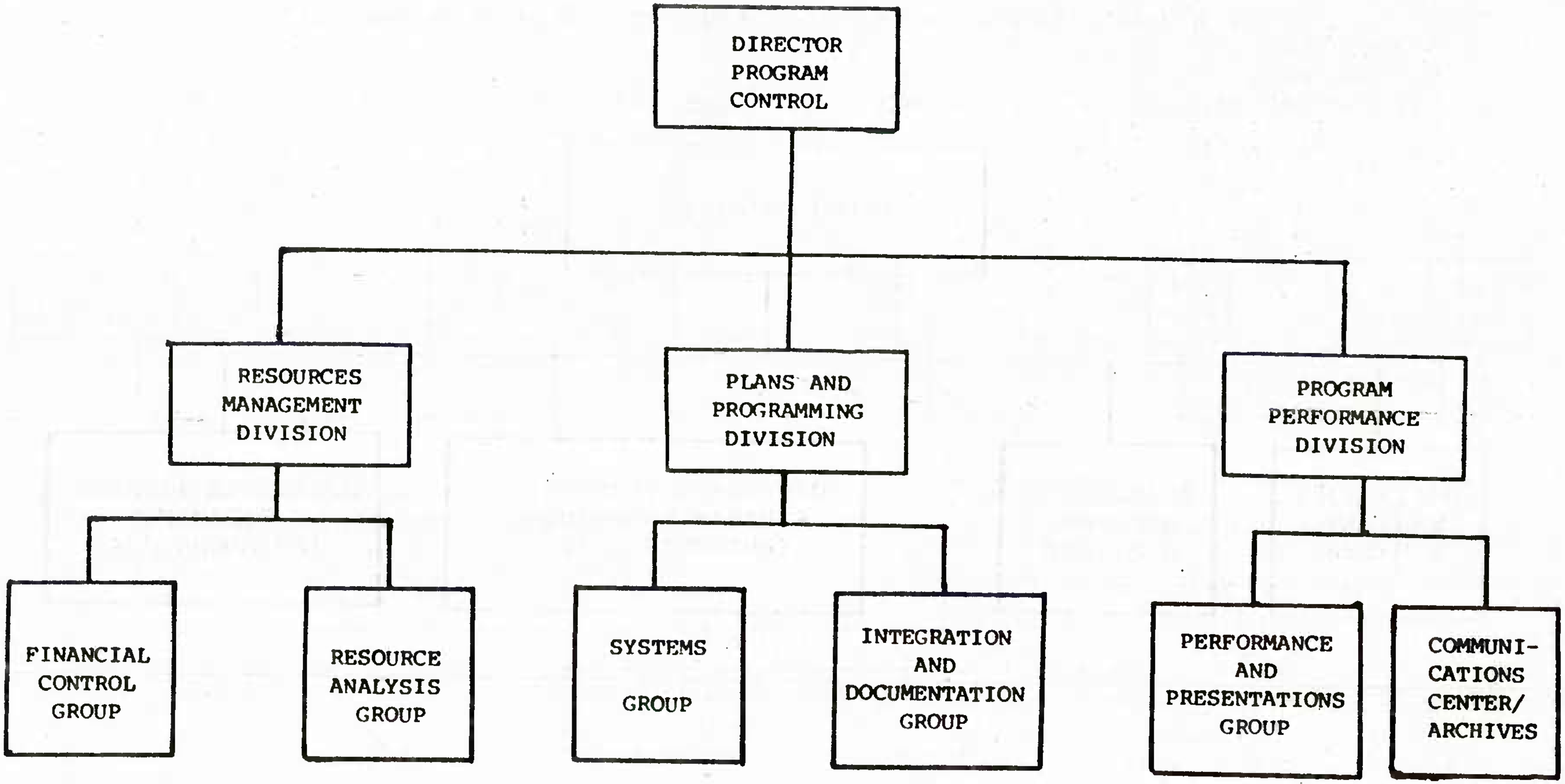
Exhibit C-5. TYPICAL ENGINEERING DIRECTORATE ORGANIZATION

CONFIGURATION MANAGEMENT



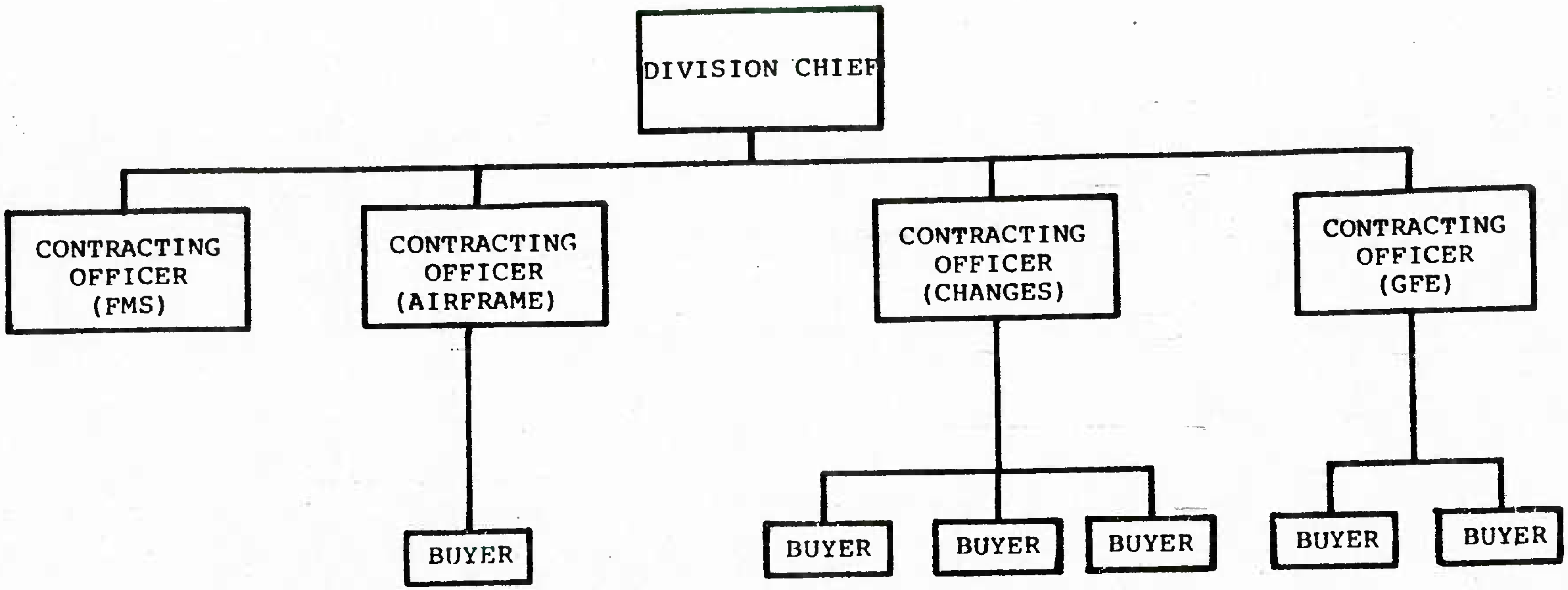
Source: Weapon System Acquisition Guide, (Air Command and Staff College, May 1981)

Exhibit C-6. TYPICAL CONFIGURATION MANAGEMENT DIRECTORATE



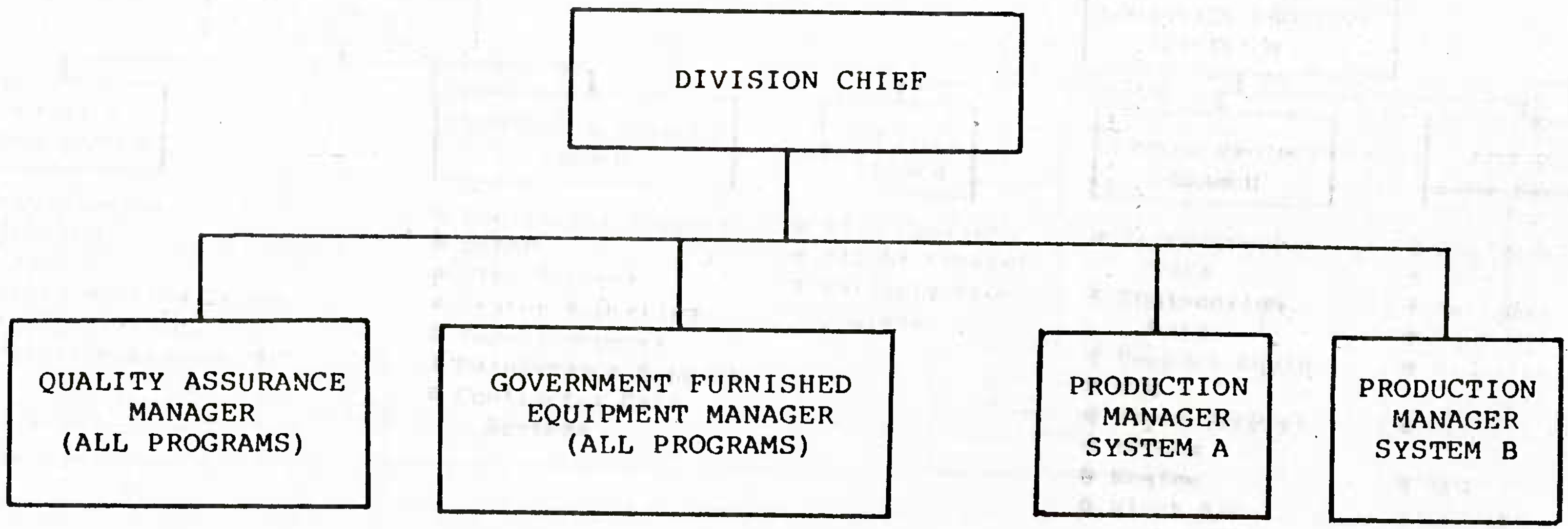
Source: Weapon System Acquisition Guide, (Air Command and Staff College, May 1981)

Exhibit C-7. ORGANIZATION OF A TYPICAL PROGRAM CONTROL/BUSINESS MANAGEMENT DIRECTORATE



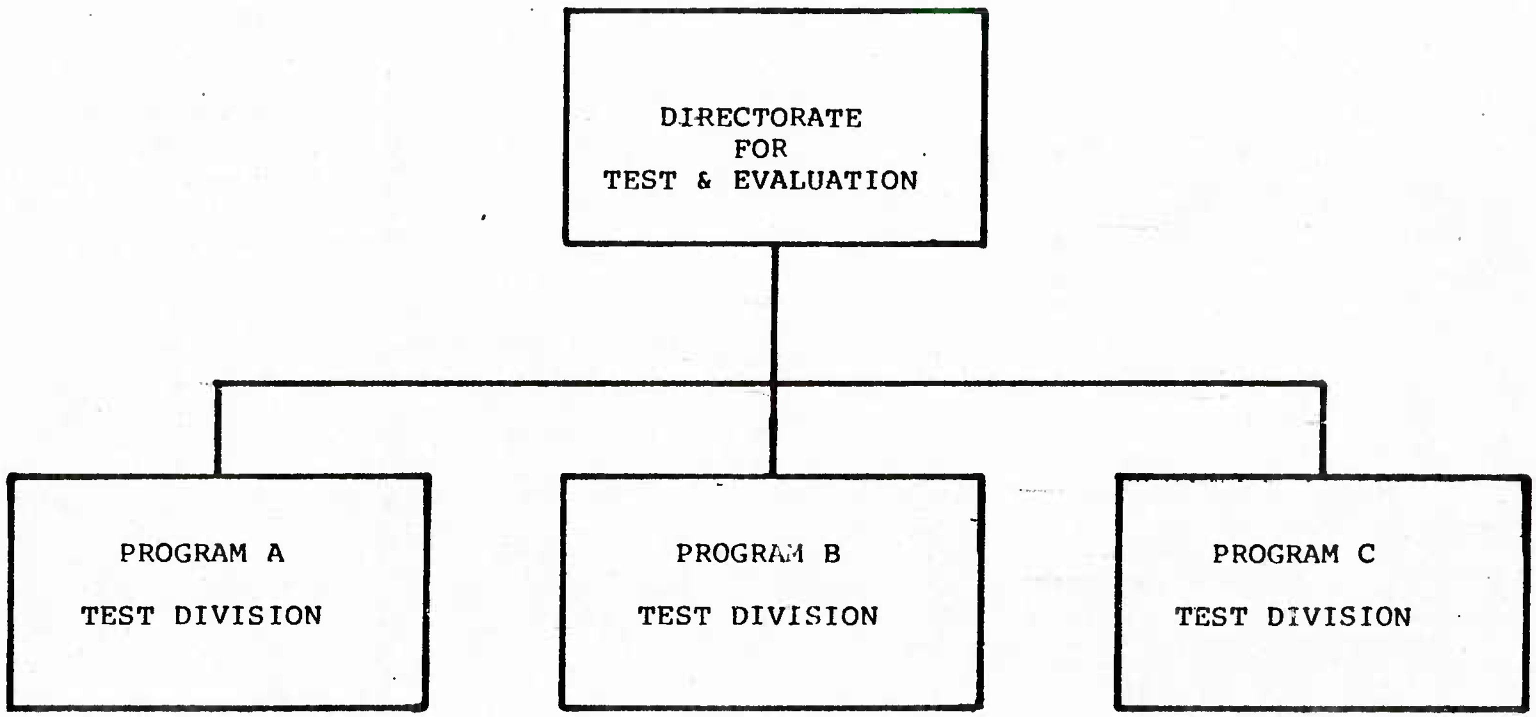
Source: Weapon System Acquisition Guide, (Air Command and Staff College, May 1981)

Exhibit C-8. TYPICAL PROGRAM OFFICE CONTRACTING DIVISION



Source: Weapon System Acquisition Guide, (Air Command and Staff College, May 1981)

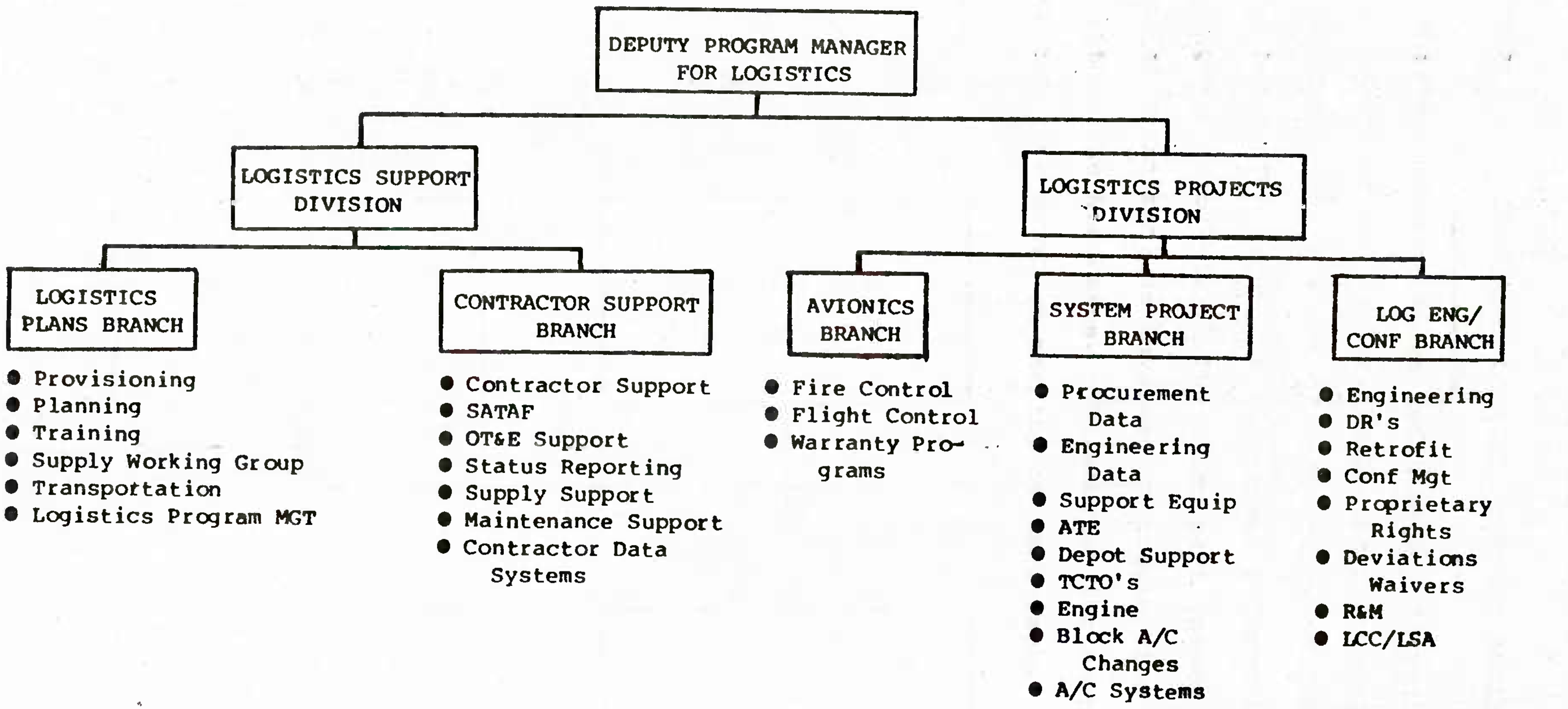
Exhibit C-9. TYPICAL PROGRAM OFFICE MANUFACTURING DIVISION
NOTE: MATRIXED FROM A REMOTE MANUFACTURING DIRECTORATE



Source: Weapon System Acquisition Guide, (Air Command and Staff College, May 1981)

Exhibit C-10. TYPICAL TEST & EVALUATION DIRECTORATE FOR MULTIPLE PROGRAM PO

ILS DIRECTORATE ORGANIZATION AND FUNCTIONS



Source: Weapon System Acquisition Guide, (Air Command and Staff College, May 1981)

Exhibit C-11. TYPICAL ILS ORGANIZATION

APPENDIX D

ADDITIONAL LOGISTIC SUPPORT ANALYSIS INFORMATION

APPENDIX D. ADDITIONAL LOGISTIC SUPPORT ANALYSIS INFORMATION

This appendix provides additional information on Logistic Support Analysis and Integrated Logistic Support. It has three parts. The first is a set of definitions of ILS elements (pages D-1 to D-3). The second is additional information on LSA tasking (pages D-4 to D-11). The third part (pages D-12 to D-15) is a list of organizations involved in acquisition logistics management within the Air Force. The sources for each of the sets of information are noted on the top of each page.

DEFINITIONS

1. ILS Elements

a. Maintenance Planning. The process conducted to evolve and establish maintenance concepts and requirements for the lifetime of a materiel system.

b. Manpower and Personnel. The identification and acquisition of military and civilian personnel with the skills and grades required to operate and support a materiel system over its lifetime at peacetime and wartime rates.

c. Supply Support. All management actions, procedures, and techniques used to determine requirements to acquire, catalog, receive, store, transfer, issue, and dispose of secondary items. This includes provisioning for initial support as well as replenishment supply support.

d. Support Equipment. All equipment (mobile or fixed) required to support the operation and maintenance of a materiel system. This includes associated multiuse end items, ground-handling and maintenance equipment, tools, metrology and calibration equipment, test equipment, and automatic test equipment. It includes the acquisition of logistics support for the support and test equipment itself.

e. Technical Data. Recorded information regardless of form or character (such as manuals and drawings) of a scientific or technical nature. Computer programs and related software are not technical data; documentation of computer programs and related software are. Also excluded are financial data or other information related to contract administration.

f. Training and Training Support. The processes, procedures, techniques, training devices, and equipment used to train civilian and active duty and reserve military personnel to operate and support a materiel system. This includes individual and crew training; new equipment training; initial, formal, and on-the-job training; and logistic support planning for training equipment and training device acquisitions and installations.

g. Computer Resources Support. The facilities, hardware, software, documentation, manpower, and personnel needed to operate and support embedded computer systems.

h. Facilities. The permanent or semipermanent real property assets required to support the materiel system, including conducting studies to define types of facilities or facility improvements, locations, space needs, environmental requirements, and equipment.

i. Packaging, Handling, Storage, and Transportation. The resources, processes, procedures, design considerations, and methods to ensure that all system, equipment, and support items are preserved, packaged, handled, and transported properly, including environmental considerations, equipment preservation requirements for short- and long-term storage, and transportability.

j. Design Interface. The relationship of logistics-related design parameters, such as R&M, to readiness and support resource requirements. These logistics-related design parameters are expressed in operational terms rather than as inherent values and specifically relate to system readiness objectives and support costs of the materiel system.

2. Integrated Logistics Support. A disciplined, unified, and iterative approach to the management and technical activities necessary to:

a. Integrate support considerations into system and equipment design.

b. Develop support requirements that are related consistently to readiness objectives, to design, and to each other.

c. Acquire the required support.

d. Provide the required support during the operational phase at minimum cost.

3. Logistics Support Analysis. The selective application of scientific and engineering efforts undertaken during the acquisition process, as part of the systems engineering process, to assist in:

a. Causing support considerations to influence design.

b. Defining support requirements that are related optimally to design and to each other.

c. Acquiring the required support.

d. Providing the required support during the operational phase at minimum cost.

4. Objective. A quantitative or qualitative criterion established as a cost, schedule, performance, or system readiness requirement. The term includes Decision Coordinating Paper (DCP) thresholds as well as lower tier requirements such as the Master Plan criteria and contract requirements.

5. Post-Production Support. Systems management and support activities necessary to ensure continued attainment of system readiness objectives with economical logistic support after cessation of production of the end item (weapon system or equipment).

6. Reliability-Centered Maintenance. A systematic approach for identifying preventive maintenance tasks for an end item in accordance with a specified set of procedures and for establishing intervals between maintenance tasks.

7. Supportability. The degree to which system design characteristics and planned logistics resources, including manpower, meet system peacetime readiness and wartime utilization requirements.

8. Support Acquisition Costs. Selected development and procurement costs associated with a system during the acquisition phase that are required to ensure that planned support of the weapon system is achieved.

9. System Readiness Objective. A criterion for assessing the ability of a system to undertake and sustain a specified set of missions at planned peacetime and wartime utilization rates. System readiness measures take explicit account of the effects of system design R&M, the characteristics and performance of the support system, and the quantity and location of support resources. Examples of system readiness measures are combat sortie rate over time, peacetime mission capable rate, operational availability, and asset ready rate.

10. Threshold. A quantitative requirement, documented in the DCP and Secretary of Defense Decision Memorandum, against which acquisition program achievements are measured. Breach of a threshold (actual or projected) requires notification of the Defense Acquisition Executive.

11. Transportability. The capability of materiel to be moved by towing, self-propulsion, or carrier through any means, such as railways, highways, waterways, pipelines, oceans, and airways (as defined in JCS Pub 1, reference (u)). (Full consideration of available and projected transportation assets, mobility plans and schedules, and the impact of system equipment and support items on the strategic mobility of operating military forces is required to achieve this capability.)

12. Weapon Support and Logistics R&D. Technology programs funded outside the weapon system development programs that may result in improved subsystem R&M, improved support elements needed in the operation and maintenance of weapon systems, and improved logistics infrastructure elements.

TABLE I. Index of Logistic Support Analysis Tasks.

TASK SECTION	PURPOSE OF TASK SECTION	TASK/SUBTASK	INFLUENCE * SYS/EQUIP DESIGN	SUPPT SYS DESIGN	LOG REQMTS DETER-MINATION
100 - PROGRAM PLANNING & CONTROL	TO PROVIDE FOR FORMAL PROGRAM PLANNING AND REVIEW ACTIONS	101 - DEVELOPMENT OF AN EARLY LOGISTIC SUPPORT ANALYSIS STRATEGY	PRIMARY PURPOSE OF 100 SERIES TASKS IS THE MANAGEMENT AND CONTROL OF THE LSA PROGRAM		
		101.2.1 - LSA STRATEGY			
		101.2.2 - UPDATES			
		102 - LOGISTIC SUPPORT ANALYSIS PLAN			
		102.2.1 - LSA PLAN			
		102.2.2 - UPDATES			
		103 - PROGRAM AND DESIGN REVIEWS			
		103.2.1 - ESTABLISH REVIEW PROCEDURES			
		103.2.2 - DESIGN REVIEWS			
		103.2.3 - PROGRAM REVIEWS			
		103.2.4 - LSA REVIEW			
200 - MISSION & SUPPORT SYSTEMS DEFINITION	TO ESTABLISH SUPPORTABILITY OBJECTIVES AND SUPPORTABILITY RELATED DESIGN GOALS, THRESHOLDS, AND CONSTRAINTS THROUGH COMPARISON WITH EXISTING SYSTEMS AND ANALYSES OF SUPPORTABILITY, COST, AND READINESS DRIVERS	201 - USE STUDY			
		201.2.1 - SUPPORTABILITY FACTORS	X	X	
		201.2.2 - QUANTITATIVE FACTORS	X	X	
		201.2.3 - FIELD VISITS	X	X	
		201.2.4 - USE STUDY REPORT AND UPDATES	X	X	
		202 - MISSION HARDWARE, SOFTWARE, AND SUPPORT SYSTEM STANDARDIZATION			
		202.2.1 - SUPPORTABILITY CONSTRAINTS	X	X	X
		202.2.2 - SUPPORTABILITY CHARACTERISTICS	X		
		202.2.3 - RECOMMENDED APPROACHES	X	X	
		202.2.4 - RISKS	X	X	X

* X INDICATES THAT THE SUBTASK IS ORIENTED TOWARD INFLUENCING THE INDICATED FACTOR(S).

TABLE I. Index of Logistic Support Analysis Tasks. - Continued

TASK SECTION	PURPOSE OF TASK SECTION	TASK/SUBTASK	INFLUENCE * SYS/EQUIP DESIGN	SUPPT SYS DESIGN	LOG REQMTS DETER-MINATION
		203 - COMPARATIVE ANALYSIS			
		203.2.1 - IDENTIFY COMPARATIVE SYSTEMS	X	X	
		203.2.2 - BASELINE COMPARISION SYSTEM	X	X	
		203.2.3 - COMPARATIVE SYSTEM CHARACTERISTICS	X	X	
		203.2.4 - QUALITATIVE SUPPORTABILITY PROBLEMS	X	X	
		203.2.5 - SUPPORTABILITY, COST, AND READINESS DRIVERS	X	X	
		203.2.6 - UNIQUE SYSTEM DRIVERS	X	X	
		203.2.7 - UPDATES	X	X	
		203.2.8 - RISKS AND ASSUMPTIONS	X	X	
		204 - TECHNOLOGICAL OPPORTUNITIES			
		204.2.1 - RECOMMENDED DESIGN OBJECTIVES	X	X	
		204.2.2 - UPDATES	X	X	
		204.2.3 - RISKS	X	X	
		205 - SUPPORTABILITY AND SUPPORTABILITY RELATED DESIGN FACTORS			
		205.2.1 - SUPPORTABILITY CHARACTERISTICS		X	
		205.2.2 - SUPPORTABILITY OBJECTIVES & ASSOCIATED RISKS	X	X	
		205.2.3 - SPECIFICATION REQUIREMENTS	X	X	
		205.2.4 - NATO CONSTRAINTS	X	X	
		205.2.5 - SUPPORTABILITY GOALS AND THRESHOLDS	X	X	

TABLE I. Index of Logistic Support Analysis Tasks. - Continued

TASK SECTION	PURPOSE OF TASK SECTION	TASK/SUBTASK	INFLUENCE *		
			SYS/EQUIP DESIGN	SUPPT SYS DESIGN	LOG REQMTS DETER-MINATION
300 - PREPARATION AND EVALUATION OF ALTERNATIVES	TO OPTIMIZE THE SUPPORT SYSTEM FOR THE NEW ITEM AND TO DEVELOP A SYSTEM WHICH ACHIEVES THE BEST BALANCE BETWEEN COST, SCHEDULE, PERFORMANCE, AND SUPPORTABILITY	301 - FUNCTIONAL REQUIREMENTS IDENTIFICATION			
		301.2.1 FUNCTIONAL REQUIREMENTS		X	
		301.2.2 UNIQUE FUNCTIONAL REQUIREMENTS		X	
		301.2.3 RISKS		X	
		301.2.4 OPERATIONS AND MAINTENANCE TASKS		X	X
		301.2.5 DESIGN ALTERNATIVES	X		
		301.2.6 UPDATES		X	X
		302 - SUPPORT SYSTEM ALTERNATIVES			
		302.2.1 ALTERNATIVE SUPPORT CONCEPTS		X	
		302.2.2 SUPPORT CONCEPT UPDATES		X	
		302.2.3 ALTERNATIVE SUPPORT PLANS		X	
		302.2.4 SUPPORT PLAN UPDATES		X	
		302.2.5 RISKS		X	
		303 - EVALUATION OF ALTERNATIVES AND TRADEOFF ANALYSIS			
		303.2.1 TRADEOFF CRITERIA	X	X	X
		303.2.2 SUPPORT SYSTEM TRADEOFFS		X	
		303.2.3 SYSTEM TRADEOFFS	X	X	
		303.2.4 READINESS SENSITIVITIES	X	X	
		303.2.5 MANPOWER AND PERSONNEL TRADEOFFS	X	X	X
		303.2.6 TRAINING TRADEOFFS	X	X	X
		303.2.7 REPAIR LEVEL ANALYSES		X	X
		303.2.8 DIAGNOSTIC TRADEOFFS	X	X	
		303.2.9 COMPARATIVE EVALUATIONS		X	
		303.2.10 ENERGY TRADEOFFS	X	X	X
		303.2.11 SURVIVABILITY TRADEOFFS	X	X	
		303.2.12 TRANSPORTABILITY TRADEOFFS	X	X	

TABLE I. Index of Logistic Support Analysis Tasks. - Continued

TASK SECTION	PURPOSE OF TASK SECTION	TASK/SUBTASK	INFLUENCE * SYS/EQUIP DESIGN	SUPPT SYS DESIGN	LOG REQMTS DETER-MINATION
400 - DETERMINATION OF LOGISTIC SUPPORT RESOURCE REQUIREMENTS	TO IDENTIFY THE LOGISTIC SUPPORT RESOURCE REQUIREMENTS OF THE NEW SYSTEM IN ITS OPERATIONAL ENVIRONMENT(S) AND TO DEVELOP PLANS FOR POST PRODUCTION SUPPORT	401 - TASK ANALYSIS			
		401.2.1 TASK ANALYSIS			X
		401.2.2 ANALYSIS DOCUMENTATION			X
		401.2.3 NEW/CRITICAL SUPPORT RESOURCES			X
		401.2.4 TRAINING REQUIREMENTS AND RECOMMENDATIONS			X
		401.2.5 DESIGN IMPROVEMENTS	X	X	
		401.2.6 MANAGEMENT PLANS			X
		401.2.7 TRANSPORTABILITY ANALYSIS	X	X	
		401.2.8 PROVISIONING REQUIREMENTS			X
		401.2.9 VALIDATION	X	X	X
		401.2.10 ILS OUTPUT PRODUCTS			X
		401.2.11 LSAR UPDATES	X	X	X
		402 - EARLY FIELDING ANALYSIS			
		402.2.1 NEW SYSTEM IMPACT			X
		402.2.2 SOURCES OF MANPOWER AND PERSONNEL SKILLS			X
		402.2.3 IMPACT OF RESOURCE SHORTFALLS			X
		402.2.4 COMBAT RESOURCE REQUIREMENTS			X
		402.2.5 PLANS FOR PROBLEM RESOLUTION			X
		403 - POST PRODUCTION SUPPORT ANALYSIS			
		403.2 POST PRODUCTION SUPPORT PLAN		X	X
500 - SUPPORTABILITY ASSESSMENT	TO ASSURE THAT SPECIFIED REQUIREMENTS ARE ACHIEVED AND DEFICIENCIES CORRECTED	501 - SUPPORTABILITY TEST, EVALUATION, AND VERIFICATION			
		501.2.1 TEST AND EVALUATION STRATEGY	X	X	X
		501.2.2 OBJECTIVES AND CRITERIA	X	X	X
		501.2.3 UPDATES AND CORRECTIVE ACTIONS	X	X	X
		501.2.4 SUPPORTABILITY ASSESSMENT PLAN (POST DEPLOYMENT)	X	X	X
		501.2.5 SUPPORTABILITY ASSESSMENT (POST DEPLOYMENT)	X	X	X

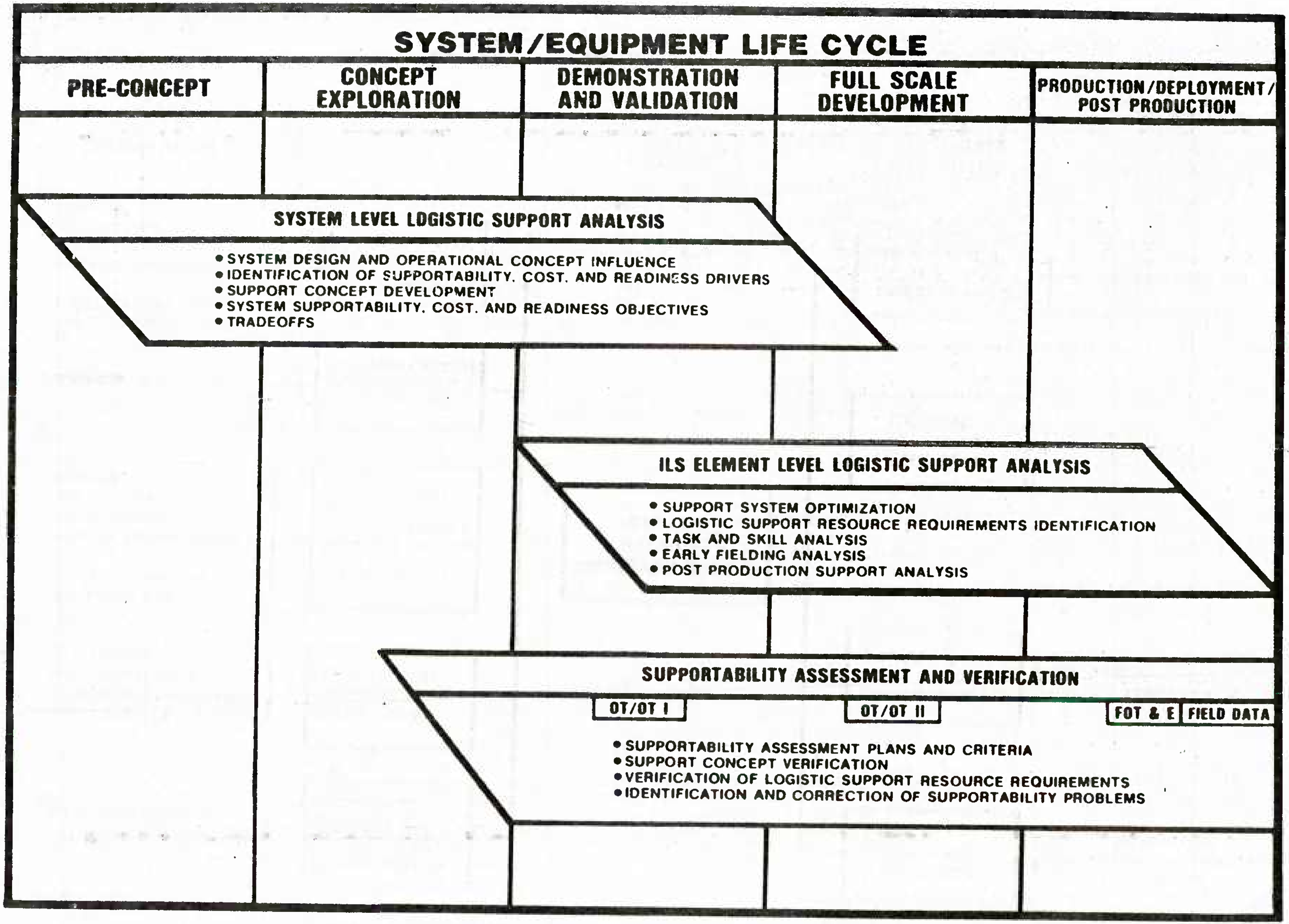


FIGURE 1. Logistic Support Analysis Process Objectives by Program Phase.

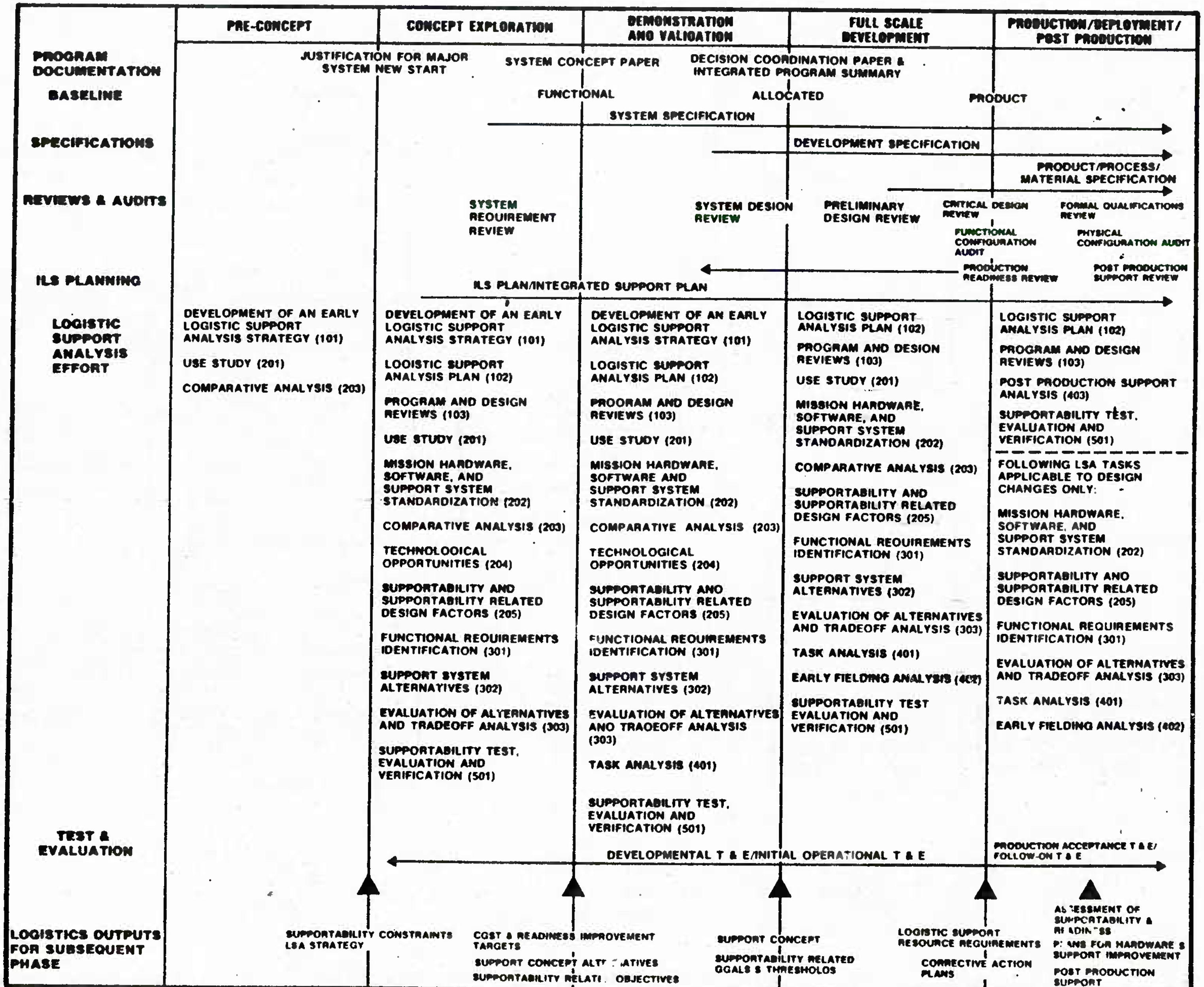


FIGURE 2. Logistic Support Analysis Process Overview.

D-9

MIL-STD-1388-1A
April 11, 1983

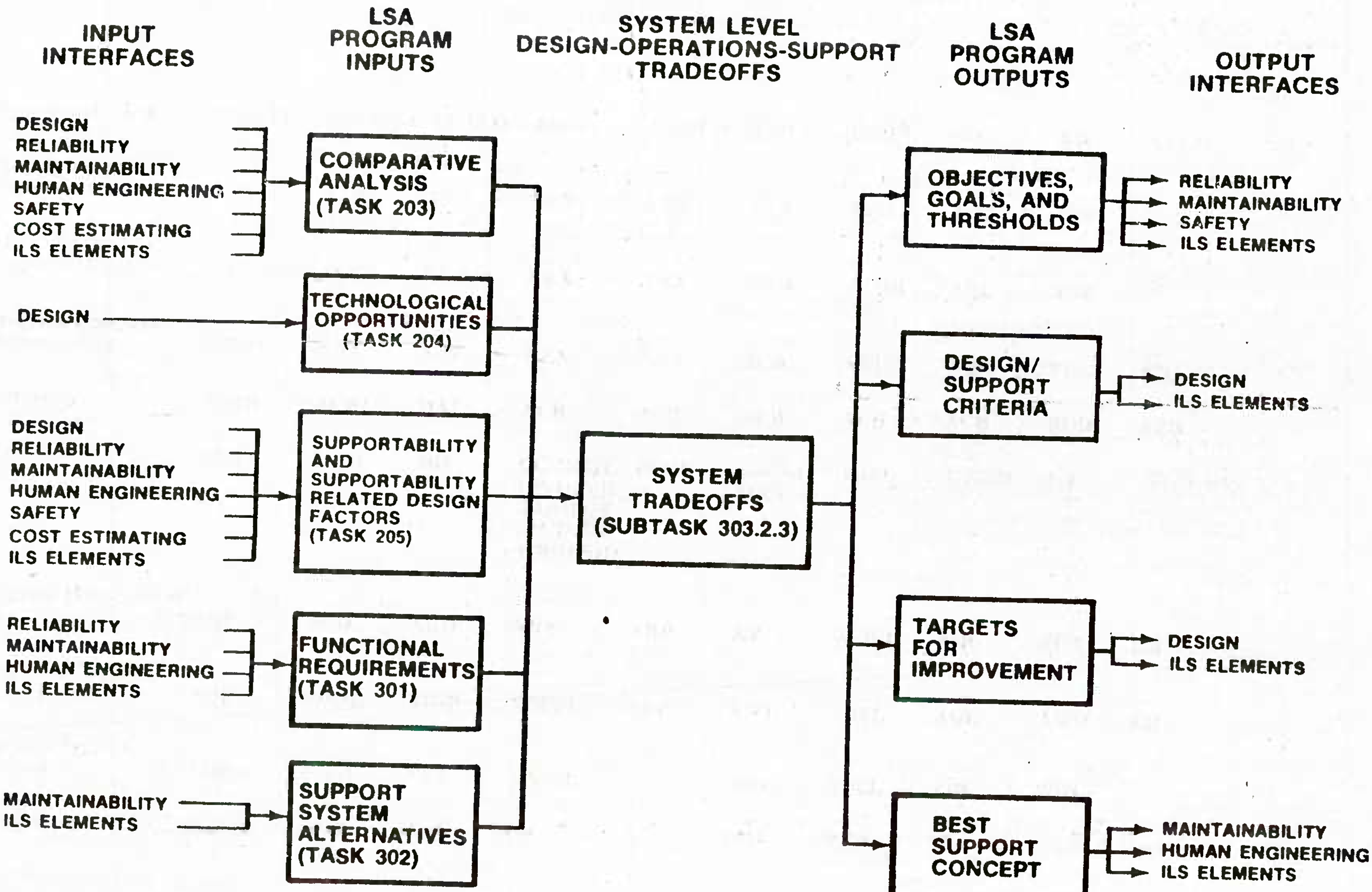


FIGURE 4. System Level Logistic Support Analysis Interfaces.

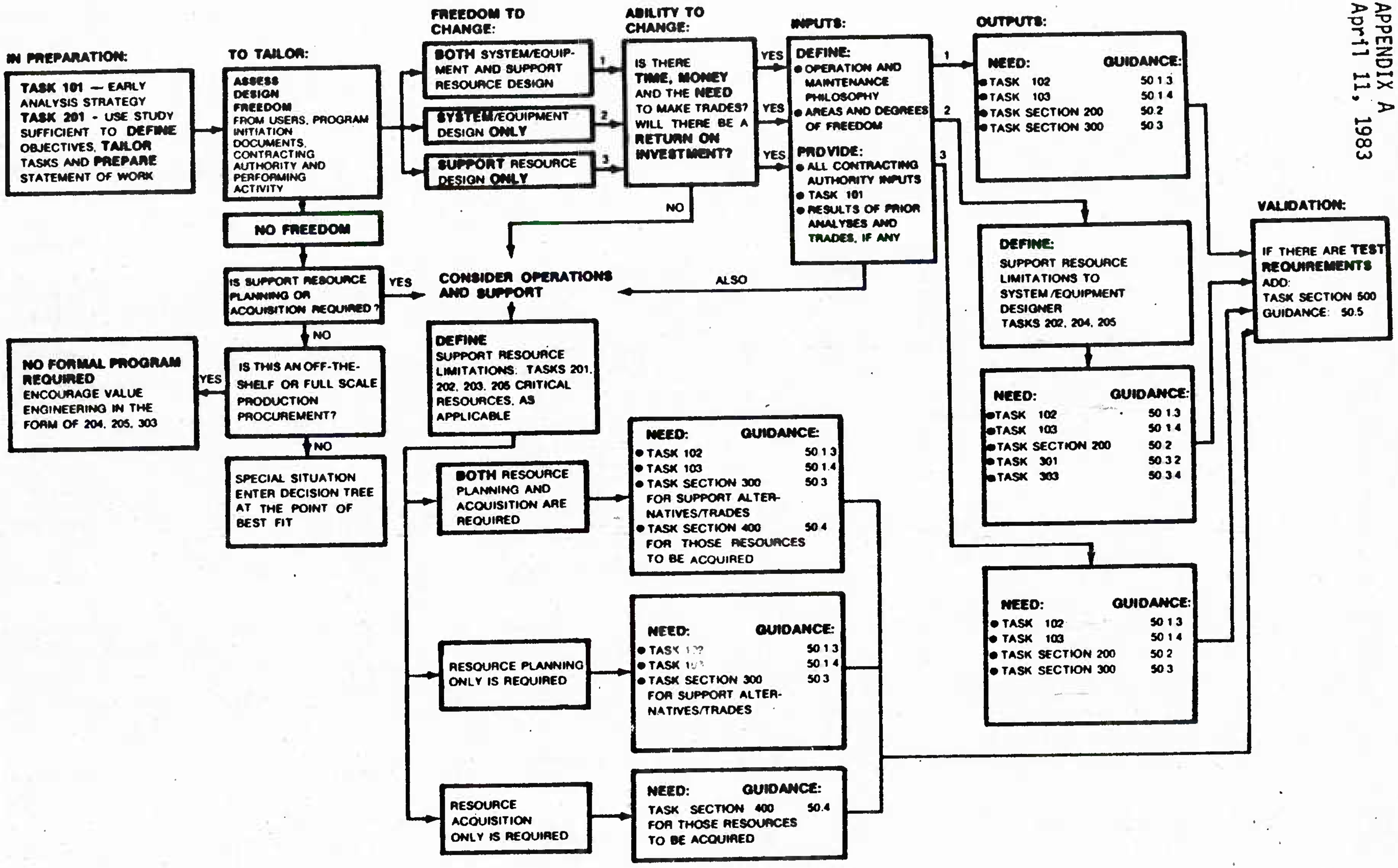


FIGURE 5. Logistic Support Analysis Tailoring Decision Logic.

ACQUISITION LOGISTICS MANAGEMENT

ORGANIZATIONAL CONTACTS

(BY SYMBOL)

Functional Area	HQ AFLC	HQ AFSC	AFALD	ALCs	AGMC	ASD	ESD	SD	AD	AFCMD	BMO
Operational Requirements	AQP	XRX	XRP	XRX	XRX	XRA	XRU	AQL	TEP	ENE	
AFLC PAD/AFSC Program Direction	AQP/LOAP	ACB	XRP	XRX	XRX	XRM	ACBB	AQL	SDE	—	
Program Objective Memorandum	XRPM	XRX	XRP	XRX	XRX	ACB	XRU	AQL	SDE	EN	
Budgeting	ACBB	ACB	DAJ	ACB	ACB	ACB	ACB	ACB	SDD	ACB	
Manpower	DPQW	MPM	MO	OC/DPQT OO/DPQH SA/DPQK SM/DPQC WR/DPQD	DPQN	6592nd MES	TOSL	MET27	SDX	MET DET 25	
Program Management Plan	AQP	SDD	XRIP	XRX	XRP	AV	ACBB	AQL	SDX	EN	
Integrated Logistics Support Plan	AQP	SDDL	XRIP	MMML	XRP	AWL	TOSL	AQL	AWO	EN	
Logistics Support Analysis	AQP	SDDL	XRS	MMML		AWL	TOSL	AQL	SQD		
Contracting	PMPM	PMP	PMY	PM		PMI	PKP	PM	PMR	TMD	
Interim Contractor Support	AQP	SDDL	XRIG	MMMM	N/A	AWL	TOSL	AQL	SQD	N/A	
Modifications	LOAP	XR	PTE	MMM	N/A	AWZ	TOSL	AQM	SDE	EN	

Functional Area	HQ AFLC	HQ AFSC	AFALD	ALCs	AGMC	ASD	ESD	SD	AD	AFCMD	BMO
Work Breakdown Structure	AQP	SDDE	XRIP	MMED	MLTP	ENS	ACC	AQL	SDE	N/A	
Data Management	LOLC	ACDR	PTQA	MMMR	MLTS	AWZ	TOSC	ACD	SDB	ACDC	
Configuration Management	LOLM	SDDE	PTQA	MMMM	XRP	AWZ	TOSC	AQM	SDB	N/A	
Provisioning	LOLC	SDDL	XRIG	MMIS	N/A	AWL	TOSL	AQL	AWO	N/A	
Depot Activation Planning	MAX	SDDL	XRIG	N/A	XRX	AWL	TOSL	DEE	AWO	N/A	
Government Furnished Equipment	LORR	SDDE	XRIP	MMMS	N/A	PMD	TOM	AQM	AWO	N/A	
Support Equip	LOLC	SDDL	SDE	MMIS	AGL/ML	AWL/ AEG	TOSL	AQL	SDL	N/A	LGN
Test & Evaluation	AQT	TEV	PTQT	MMM	XRX	AWB	TOET	AQT	TET	EPE	ENSS
Foreign Military Sales	MI	SDI	AQI SDM	MM	MM	AV	FA	YK/ ACB	ACB	XRF	ENMP
Life Cycle Costing/ Design-To-Cost	AQP	SDDL	XRSC	MMEA	XRX	ACL	TOET	AQL	SDB	EPL/ENE	PCC
Contractual Tech. for Supportability	N/A	PMP	PPEX	N/A	N/A	AWL	PKP	AQL	PMP	ACOC	PM
Program Management Respon. Transfer	AQP	SDDS	XRIP	MMM		AV	TOSL	AQL	SD3	N/A	LGX
Management Reports	AQP	SDDE	SDM	MMML		ADOM	ACDD	ACDD	ACRM	TMO	PC

Functional Area	HQ AFLC	HQ AFSC	AFALD	ALCs	AGMC	ASD	ESD	SD	AD	AFCMD	BMO
Technical Orders	LOLM AQT	SDDL	PTQA	MMED	MLTP	AWL	TOSC	AQL	SDE	EPX/EPE	SDHP
Packaging	LOZP	LGT	PTPP	DSPC (except OO-ALC/DSTC	SODS	AWL	TOSL	AQL	SD3	PDT	SDML
Product Assurance						ENO	TOM	SDE			
Transportation	LOZP	LGTM	N/A	DSPP except OO-ALC/DSTM	SODS	AWL	TOST	AQL	SD3	PDT	SDML
Quality Assurance	QA	SDDE	PTQA	QE	QE	PMD	TOET	AQT	SDE	QAX	AWQA
Calibration and Metrology	MAXF	LGMW	PTEE	MMIR	MLTP	ENEG	TOSL	AQT	N/A	N/A	N/A
Training	DPCT	DPCT	DAJ	DPCT	DPCT	AWL	ATC XPQE	AQM	DPT	DP	DP
Facilities	DEPR	DEP	N/A	DEPD	DEPD	DES	DE	DEE	DEE	PDX	ENBF
System Engineering	AQT	SDDE	PTE	MM-R (A, S, C, G, W)	N/A	ENS	TOET	AQT	SDE	EPE	EN
Survivability	LOEA	SDDE	PTEE	OO/MMET OC/MMEA SA/MMET SM/MMEA WR/MMET	SN	ENFT	TOET		SDE	EPE	ENSN
Reliability	LOEP	SDDE	PTQT	MMEA	XRS	ENES	TOET	AQT	SDE	EPE	AWQR
Maintainability	LOEP	SDDE	PTQT	MMEA	XRS	ENES	TOET	AQL	SDE	EPE	LGN
Pre-operational Support	N/A	SDDL		N/A	N/A	AWL	TOSL	AQL	AWO	N/A	SDML

Functional Area	HQ AFLC	HQ AFSC	AFALD	ALCs	AGMC	ASD	ESD	SD	AD	AFCMD	BMO
Site Activation	AQP	SDDE	XRIG		DEE	AWL	TOET	DEE	SDE	N/A	SDMS
Engineering Data	LOLD/AQT	SDDE	PTQA	MMED/ MM-R		AWZ	TOSC	AQT	SDE	EPE/EPY	LGX
Lessons Learned	AQT	SDDE	PTQA			AV	TOSL	AQM	SDO	EPX	LGX
Computer Resources	LOE	XRF	PTE	MMEC		EN	TOI	AQM	KR	EPE/KR	EN
Interservicing	MA	SDDL	XRIG			AWL	TOSL	AQL	AWO		LG

APPENDIX E

GUIDANCE ON DEVELOPING A SCHEDULING NETWORK*

*The information contained in this appendix has been extracted verbatim from the on-line Users Guide for the Computer Supported Network Analysis System (CSNAS), owned and operated by AFALC/XRI. For more information on this system, contact Mr. Albert L. Clark, AFALC/XRI, Wright-Patterson AFB, OH. Autovon 785-6725

APPENDIX E. GUIDANCE ON DEVELOPING A SCHEDULING NETWORK

This appendix provides a brief plan for developing a program schedule network. It has been extracted intact from the on-line Users Guide for the Computer Supported Network Analysis System (CSNAS), owned and operated by AFALC/XRI. While largely intended to assist Deputy Program Managers in Logistics in planning their logistics-related activities, the model and the associated guidance quoted in this appendix, may be of larger use to the PM and his staff in balancing materiel readiness and concurrency.

NETWORK ANALYSIS

WHY

1. PURPOSE

The purpose of network analysis is to develop a logical schedule, determine the critical path, identify which jobs have how much slack time, and to integrate the separate schedules of all portions of a project. Without network analysis, the manager is not integrating the portions of a project, he has a tendency to think the wrong jobs are critical to the schedule and has everyone working in the wrong direction while time slips away.

a. The program/project manager does not understand how everything interrelates and how a slip in one area may or may not effect the overall schedule.

b. The submanager (SE manager, Engineer, Contractor, etc.) may think that his job should have all the attention at a point in time when his area has time to burn. When all the submanagers think their problem is critical and when there is no network analysis the project manager may be swayed by personality versus analysis of the problem.

c. The submanager has a tendency for tunnel vision and think he has plenty of time to do a portion of the job and not realize that someone else cannot start until he has finished. The project manager may be lashing the wrong person for "why the hold up".

2. DESIRED RESULTS

A network analysis should graphically show all concerned with a project just where each individual job fits into the whole project. Just the diagram with no dates or times can be invaluable to management, supervision, and worker. The logic diagram is the hardest part and that is why model networks have been

developed. If the program manager/DPML cannot develop the logic diagram of what jobs are done in what sequence, how can anyone possibly expect to have a good schedule.

a. The network analysis logic diagram is worth a thousand words. It is this diagram that is a main integrator between ILS and the program, between ILS elements, between the contractor and between all of the USAF commands associated with a project. An ILSP without a network analysis is only the binding together of a series of separate sub plans. the "I" in Integrated Logistics Support (ILS) is more than a compilation of plans. The network analysis shows how all of these separate entities interrelate in an integrated schedule.

b. The network analysis provides more than the typical milestone chart that is a series of guesses as to when jobs should be done. At worst a milestone chart is the product of when the contractor is going to do things versus our schedule of when we want things done by not only the contractor but everyone with a major role. Everyone should be marching to our plan versus doing their own thing and getting approval to vary from our schedule. The contractor and everyone else on the project should, of course, be involved in the development of the schedule. Without program guidance, the contractor may be delaying an item critical to the program without realizing what he is doing. The manager of a project must also be the planner and the leader to make things happen...versus just reacting to disasters.

c. A network analysis tells us what jobs are on the critical time path. This critical path tells us what jobs must stay on schedule and which jobs can slip, how much. A network analysis enables us to develop a job logic and an estimated time to do each job and provides us with an earliest start and finish time, a latest possible start and finish time, the amount of slack time on any job, and the critical time path.

d. With network analysis the manager has a logical plan, can control time better, and hopefully, the manager can deliver a supportable system in less time with equal or lower cost.

NETWORK ANALYSIS

HOW

1. STEP ONE: ESTABLISH PURPOSE OF THE PLAN:

You must decide what is this network for, who is it for, how will it be used. If it is for the program manager, only go to the level of detail that he needs to manager. If the network is intended to be the very top level schedule of key jobs...flight number 6 to deliver 5% of spares does not belong on the top level production and deployment network. It might belong on a sub-network to show the details of site activation number 7. Site activation number 7 may be a task on a sub-network to show the details of a top level task on the top levele network that is called "deploy system". When the program manager is developing a schedule to show how he will get a system from FSED to IOC he may want to know the time frame of when deployments will occur but he is not ready to look at the details of when each operational site will be activated let alone when flight number 6 is arriving. In fact the only one to worry these details will probably be the deployment manager...only if he has a problem will he tell the DPML/PM.

EXAMPLE: Sub-network for installation of ATE test set.

2. STEP TWO: TIME FRAME OF THE PLAN:

You must decide how much you are ready to plan for. You should have a network or a series of networks to cover all of FSED if you are going to send out an RFP for all of FSED. If by

chance you hve already gone on contract or already sent out that RFP it is essential that your networks cover this period.

You many want to consider including the network analysis as part of the FMP, ILSP, and RFP. The RFP should then call for the ocntractor to respond to this schedule with what is wrong with it, how he will integrate with it, and/or what his proposed network analysis indicates instead of your schedule. A network attached to his ISP would show how he proposes to integrate logistic support. This network must match our plans before we actually sign the contract. Schedule deviations should be justified by the responsible party, approved by the manager, changed in the contracts and the networks. Results of the network changes should be provided to all concerned to adjust their own networks/plans accordingly.

EXAMPLE: This sub-network will begin at SERD submittal and end when the ATE is installed at location one.

3. **STEP THREE: LIST THE JOBS (TASKS) TO BE DONE.**

You now get all of the key managers involved in making a list of the tasks that must be done to meet step one and step two above. Don't over work this area as later steps will help you find more.

EXAMPLE:
1. IDENTIFY SUPPORT EQUIPMENT
2. ORDER SUPPORT EQUIPMENT
3. LEADTIME FOR SUPPORT EQUIPMENT
4. INSTALL SUPPORT EQUIPMENT

4. **STEP FOUR: DEVELOP LOGIC/SEQUENCING.**

You must now copy all of these jobs listed in step three onto slips of paper. You can start at either the front or back of a problem. We recommend that you start with finish and work backwards. Use a blank wall, a large table top, a sheet of butcher paper, etc. Put up a task slip on the far right hand side that says "finish". Put up the task slip that appears to be the last job required before the finish of the network. Now ask the group, "is there any other job that must be done after this job and before we have finished?". When this has been done put up the next task slip representing some job that is done prior to the last job you put up and ask the questions...is the last job dependent upon this job in any way, is there any job that must be done after this one but before the last job????. Repeat this process until you have worked your way back to today. If your plan starts growing in size and becoming overly complex, take a look at the job descriptions again to make sure that you are sticking to your decisions in step one and two. Are you getting into too much detail? Is each task of sufficient importance to be included on this plan or does it apply more to lower level management? Remember that the ultimate limit is 400 tasks and anything over 200 is very difficult to understand. Draw lines between dependent tasks from finish to start. If one job can start when another is half complete break the predecessor job into two, half complete and all complete. Add an OPR for each job to show who's responsible. If your network is too big you may have tried to cover too long a period of time or gotten into too much detail.

EXAMPLE:

IDENTIFY SPT EQUIP CONTRACTOR	ORDER SUPPRT EQUIPMENT SE MANAGER	LEADTIME FOR SPT EQUIPMENT AFLC	INSTALL SPT EQMT USING CMD

5. **STEP FIVE: TIME THE JOBS/TASKS**

You can load the network into the computer with zero time tasks. If you are just working out the logic and are not ready to consider work times we suggest that you use a time of one time unit for each. That way the task duration time becomes at least a counter and will show the most numbe of jobs on a path as the critical path. If you use zero time on all the jobs, the computer will say everything must happen at once and everything is critical.

The time we are referring to is a job duration time for each job on the network. The software will accept either work days based on a 5 day workweek and computing in weekends or work weeks. If all of your networks are somehow related or will be they should all be the same, days or weeks. All model networks are in weeks, because over a planning period of years you will be lucky to come within weeks of original planning let alone hit an exact day.

There are several ways to arrive at a task duration time:

a. Contractual time

b. Task time = $\frac{\text{optimistic} + (4 \text{ x most likely}) + \text{pessimistic}}{6}$

c. Experience

d. We recommend your best educated guess and plan on changing task times as soon as you learn you guessed wrong.

e. If you want a planned schedule and a pessimistic schedule, simply do one schedule and then copy that network onto another computer file and change the task times on the new file.

YOU ARE NOW READY TO LOAD YOUR NETWORK INTO THE COMPUTER TO COMPUTE START AND FINISH DATES, CRITICAL PATH, AND SLACK TIME.

The software has an AFALC/XR imposed limit of 400 tasks per network. However, the user should limit the number of tasks to 100-150. This limit is imposed because networks should be small enough for personnel to comprehend. A second reason is because networks on a project ae meant to be update regularly to reflect the varius changes that always occur during a project. If a network is very large it takes a long time to print; it won't hang easily on a wall where it can be referred to regularly; and consequently it falls into disuse where it does not do anything or do any good for program management. Good networking dictates that you should start with a top level program network of a limited number of high level tasks that top level management is actually interested in monitoring. A top level task may than become the summation of a lower level network.

EXAMPLE: Task number 3100 on the top level network "ILST&E" becomes network file number T3100N when file T3100N is run through the software it prints the detailed tasks required to do "ILST&E.

There have been many programs that had an automated network of 7,000-10,000 Tasks that got lost in detail. A low level task or series of low level tasks were changed causing changes to the top level network tasks and the reasons got lost...The program got off schedule...and control of time was lost...The most important aspect of network analysis. Hence the user should have

sub-networks of 400 or fewer tasks that require each network to be updated independently of other networks until management has approved the changes and caused the input to each level of network.

Rather than computing sub-networks together as a single network for automatic update of all levels, this network technique calls for having each network be independent but related. If the level one network has a task number 5000 "DELIVER FIRST AIRCRAFT", then the dates for this task become mandatory on lower level networks....CONTROL... If the manager of level two network cannot meet this given date for task number 5000 then he should brief the level one network manger as to why not and how far he will miss this date. The level one manager must then either agree to input a change to task number 5000 on the level one network or force the manager of level two network to go back and work on his plans to try to meet the mandatory dates on task number 5000.

Network analysis/program control takes work...Automation helps only to a point...beyond which...control is lost.